The Engineer

DECEMBER 4, 1953 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

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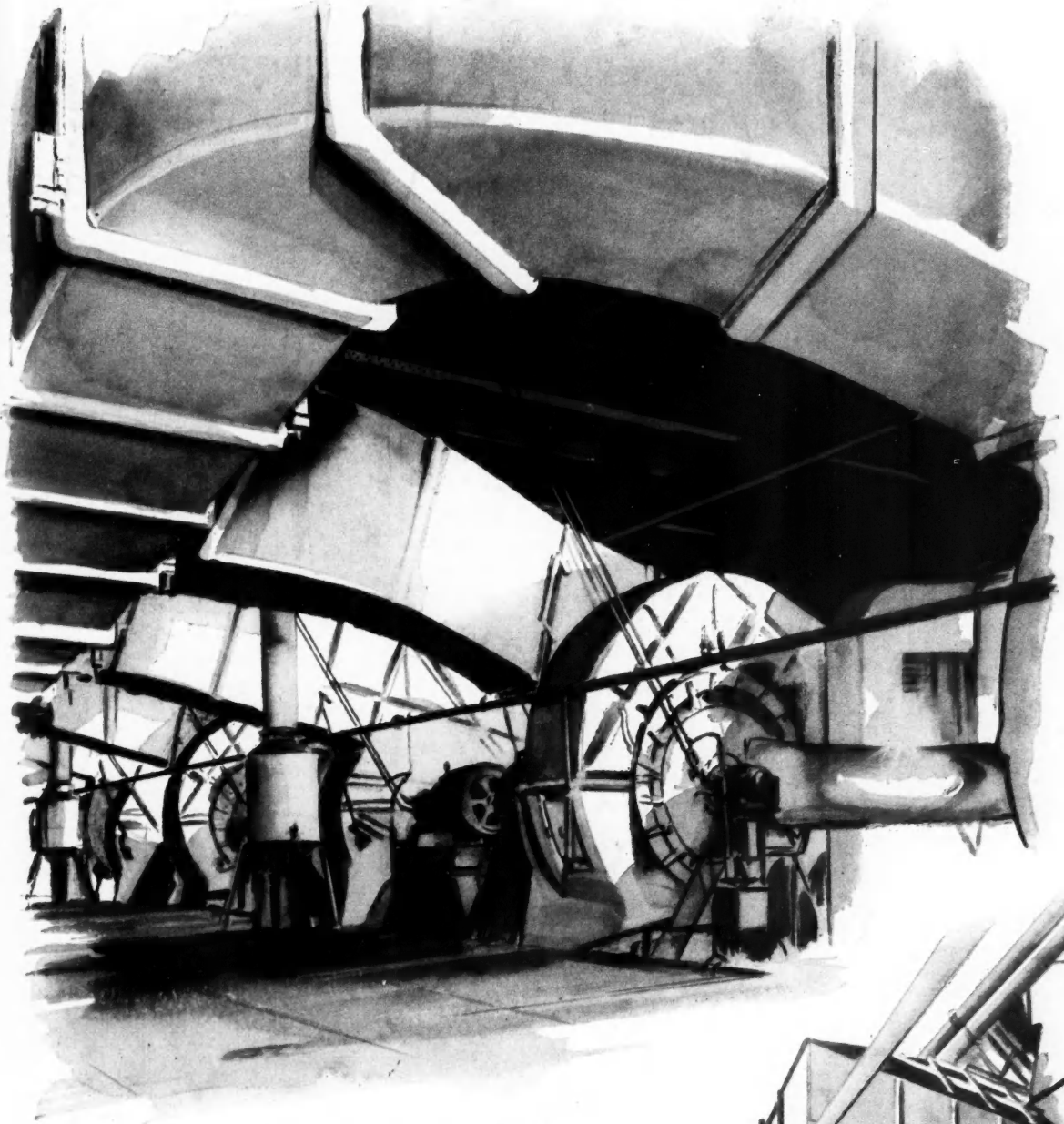

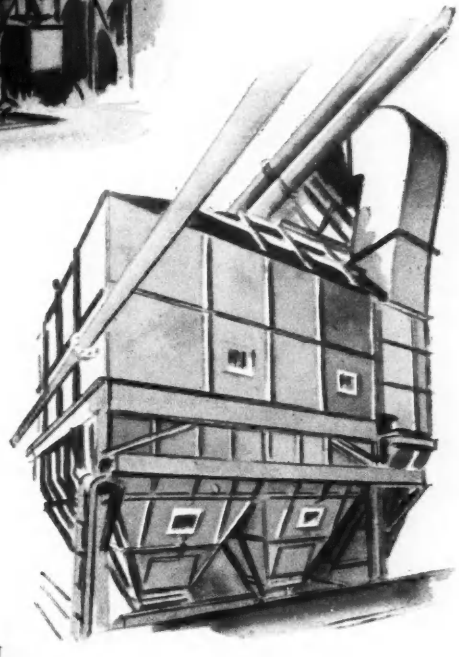

Howden induced draught fans with scroll collectors, at a south coast generating station
Below: Howden Centicell dust collectors at a London Power Station.

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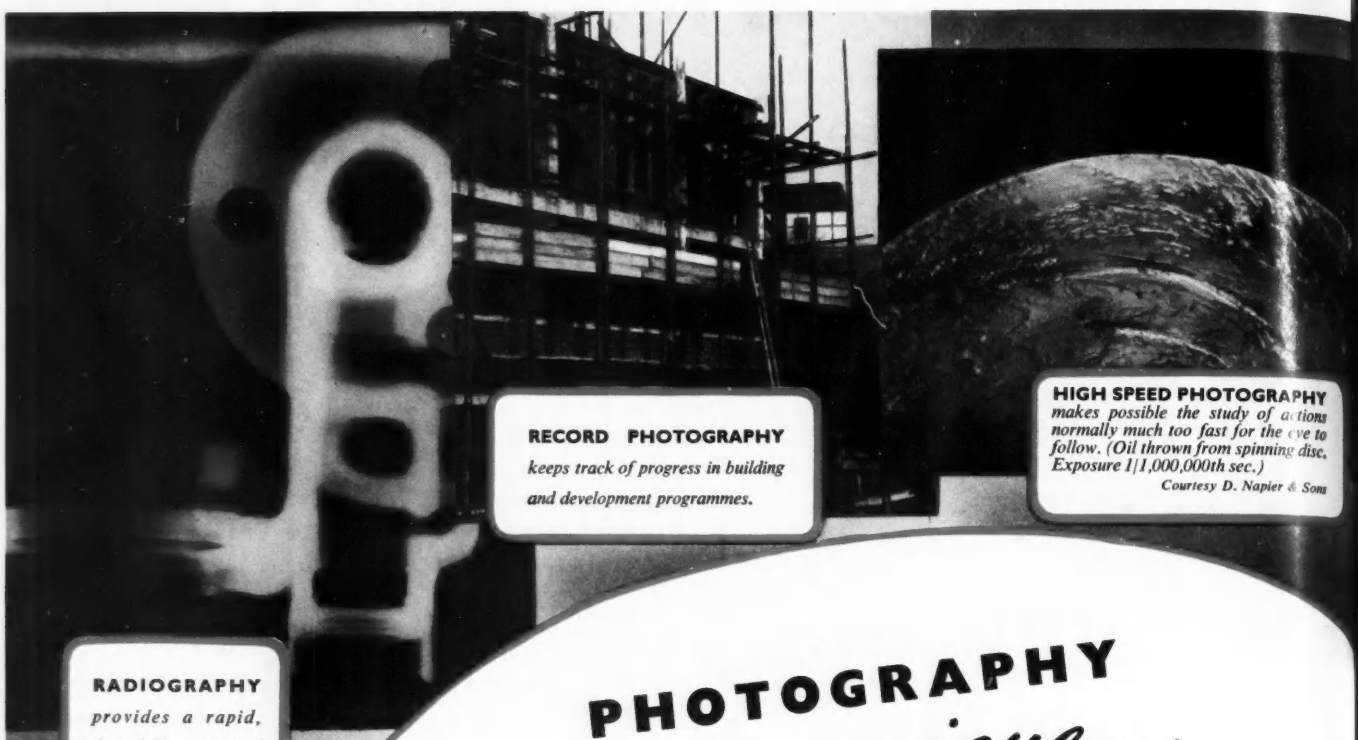
JAMES HOWDEN & COMPANY LIMITED, 195 SCOTLAND STREET, GLASGOW, C.5, and 15 GROSVENOR PLACE, LONDON, S.W.1



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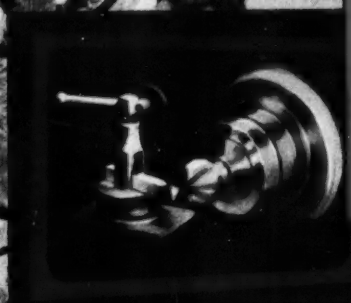

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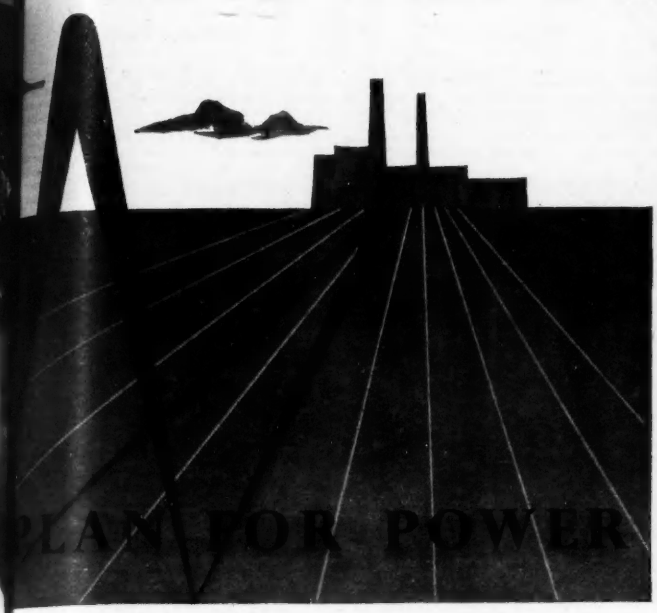

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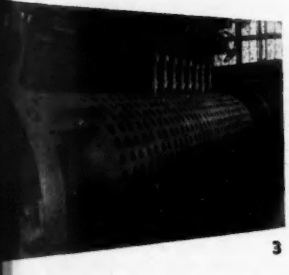

3

1. *Power expanding of tubes inside a boiler drum.*
2. *One of two Raymond Bowl Mills and exhauster fans firing one water-tube boiler.*
3. *Multiple spindle machine trepanning tube holes after fabrication.*

ATER-TUBE BOILERS BY Clarke Chapman

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THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF ADELAIDE
SOUTH AUSTRALIA

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER

Applications are invited for the position of LECTURER in the above Department.

Salary range, £A.600/£A50/£A1000, plus cost-of-living. The cost-of-living adjustment is at present £A244 8s., and it is not thought that there will be any change in that figure in the foreseeable and near future. The successful candidate's starting salary, within the range quoted, will be dependent on his qualifications and experience.

The Lecturer is required for the electrical power engineering section, and should have experience in industry and some knowledge of electrical measurements, servo-mechanisms and electronics.

Applications, in triplicate, must include particulars of age, nationality, academic record, teaching qualifications, war service (if any) and present position; a list of publications (if any); copies of testimonials; the names and addresses of two referees of whom confidential inquiries may be made; a medical certificate of good health.

Two copies of the application should reach the Registrar, University of Adelaide, Adelaide, South Australia, not later than 21st December, 1953; one copy should be sent to the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1 (from whom detailed terms of appointment may be obtained), by the same date. E6276

UNIVERSITY OF DURHAM

CHAIR OF CHEMICAL ENGINEERING

Applications are invited for the newly created CHAIR OF CHEMICAL ENGINEERING, tenable at King's College, Newcastle upon Tyne. The person appointed will take over the existing facilities for teaching and research in chemical engineering at King's College. He will be required to take up appointment not later than 1st October, 1954. Salary not less than £1750 per annum with F.S.S.U. and family allowances. Applications (12 copies), containing the names of three referees, should be lodged with the undersigned, from whom further particulars may be obtained, not later than 18th January, 1954. (Applicants from outside the British Isles may send one copy only.)

E. M. BETTENSON,
Registrar.

University Office,
46, North Bailey,
Durham. E6296

THE ROYAL TECHNICAL COLLEGE, GLASGOW
(IN AFFILIATION WITH THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

SENIOR LECTURESHIP

Applications are invited for a SENIOR LECTURESHIP in the Heat Engines Section of the Department. Candidates should have a good Honours Degree with industrial and research experience; teaching experience an advantage, but not essential.

The Engineering Courses are conducted on a sandwich system which leaves the summer term free for research, opportunities for which, because of sponsored research programmes, are exceptionally good.

Salary on scale £1150 by £50 to £1450.

Further particulars and forms of application can be obtained from the Secretary, The Royal Technical College, Glasgow. E6297

LONDON COUNTY COUNCIL

HANDICRAFT

BERMONDSEY SCHOOL

PAGES' WALK, OLD KENT ROAD, S.E.1
(CENTRE AT ROLLS ROAD, S.E.1)

QUALIFIED HANDICRAFT MASTERS

Applications invited from qualified HANDICRAFT MASTERS for appointment to Council's service and assignment to this school (220 boys, 220 girls, 11–16), to teach metalwork to G.C.E. standard. Burnham (London) scale salary.—Apply at once to Headmaster of School on Form EO/TS40, obtainable from Education Officer (EO/TS4), County Hall, S.E.1 (send stamped, addressed, foolscap envelope). (1325.) E6298

NATIONAL COAL BOARD

N.W. DIVISION

DRAUGHTSMAN (MECHANICAL)

DRAUGHTSMAN (Mechanical) required for Divisional Office. Should have good general experience in colliery or heavy engineering. Workshop experience, knowledge of plant design and layout and installation of services is desirable. Technical training to at least Higher National Certificate necessary.

Salary according to qualifications and experience.

Applications, stating age, experience and qualifications, to Establishment Officer, 40, Portland Street, M/cr. 1, by 12th December. E6268

PUBLIC APPOINTMENTS

CITY OF SALISBURY
SOUTHERN RHODESIA

CIVIL ENGINEERS AND TECHNICAL ASSISTANTS

Airmail applications for the following posts are invited and will be received by the undersigned up to and including Saturday, 2nd January, 1954.

(a) CIVIL ENGINEERS, GRADE 2.

Salary £980 by £50 to £1280 per annum.

Applicants must possess a Degree in Civil Engineering from an approved University, or be Associate Members of the Institution of Civil or Municipal Engineers, and should have had at least three years' practical experience since qualification. Municipal experience will be a recommendation. Vacancies may occur later on for Civil Engineers, Grade 1 (maximum £1500 per annum), and higher posts which are normally filled by selection.

(b) TECHNICAL ASSISTANTS, GRADE 2.

Salary £900 by £50 to £1150 per annum.

Applicants need not be qualified, but must have had considerable practical experience in municipal engineering. This grade is followed by that of Technical Assistants, Grade 1, which has a maximum salary of £1350 per annum.

General: No allowances are payable, and entry will be at the minimum of the applicable grade. The posts are pensionable, and carry generous leave privileges. Accommodation will be provided and the following travelling expenses will be paid by the Council after assumption of duty (proportionately refundable by the appointee in the event of termination of services within three years):—

Appointee: £75 plus first-class single rail fare from port of disembarkation in Africa to Salisbury.

Wife: £50.

First child, £20; subsequent children, £10 (if under the age of 16 years).

All applicants must state age, place of birth, nationality, marital state, qualifications, experience and earliest dates duties could be commenced if appointed, and should submit copies of testimonials.

W. J. JARVIS,
City Engineer.

P.O. Box 1583,
Salisbury, S. Rhodesia.
3rd December, 1953. E6320

AMENDED

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS, SCIENTIFIC OFFICERS, PATENT EXAMINER AND PATENT OFFICER CLASSES

The Civil Service Commissioners invite applications for permanent and pensionable appointments to be filled by frequent competitive interviews. The Scientific Posts are in various Government Departments and cover a wide range of scientific research and development in most of the major fields of fundamental and applied science. In biological subjects the number of vacancies is small; individual vacancies exist at present for candidates who have specialised in palaeobotany, invertebrate fossils and foraminifera. The Patent Posts are in the Patent Office (Board of Trade), Admiralty and Ministry of Supply.

Candidates must have obtained a Universrity Degree with First or Second-Class Honours in an appropriate scientific subject (including Engineering) or in Mathematics, or an equivalent qualification; or for Scientific Posts, possess high professional attainments. Candidates for Senior Scientific Officer Posts must, in addition, have had at least three years' post-graduate or other approved experience.

Age limits: Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26 may be admitted. For Scientific Officers and Patent Classes, between 21 and 28 during 1953 (up to 31 for permanent members of the Experimental Officer class competing as Scientific Officers). Inclusive London salary scales: Senior Scientific Officers, (men) £917–£1075, (women) £786–£949; Scientific Officers, (men) £440–£812, (women) £440–£707; Patent Examiner and Patent Officer Classes, (men) £440–£760, (women) £440–£576. Women's rates for Patent Classes under review. Somewhat lower rates in the Provinces.

Further particulars from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.53/53 for Senior Scientific Officers, and S.52/53, S.128/53, for the other posts. Completed application forms to be returned on or before 31st December, 1953. E6281

MINISTRY OF SUPPLY

ENGINEER (SENIOR GRADE)

The Civil Service Commissioners invite applications from men for a permanent and pensionable POST at the Atomic Energy Research Establishment, Harwell, Didcot, Berks.

The Engineer to be responsible to the Assistant Director (Design and Manufacture) for a large modern engineering workshop engaged in the manufacture of a wide range of experimental apparatus and plant.

Candidates must either be Corporate Members of one of the Institutions of Civil, Mechanical or Electrical Engineers or Associate Fellows of the Royal Aeronautical Society; or have gained exemption or equivalent qualifications after a regular engineering apprenticeship. Exceptionally a candidate without these qualifications may be considered. Candidates should have had considerable experience in the management of a manufacturing workshop and of industrial staff. Familiarity, in detail, with modern welding procedure and in progressing and planning a wide variety of work is desirable.

Age at least 30 on 1st October, 1953.

Salary scale, £1295–£1476.

Starting pay above the minimum may be granted to an exceptionally well-qualified candidate.

Good housing prospects for successful candidates.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S4267/54. Completed application forms must be returned by 22nd December, 1953. E6282

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

CENTRAL RESEARCH ESTABLISHMENT II

SCIENTISTS

National Coal Board invite applications for superannuable appointments as SCIENTISTS at their Central Research Establishment II, Isleworth, Middlesex, to work in a group studying methods of establishing suitable instrumentation for use in mines and to design and prove instruments required for use in all aspects of mining and research into mining techniques.

Candidates should have a First or Second Class Honours Degree or equivalent qualification in Physics or Engineering. Some post-graduate experience in any of the following fields is essential:—Light engineering, pneumatic and/or hydraulic mechanism design, design of light electrical, electronic or optical mechanisms.

Appointments will be in the grade of either Scientist II (£645 by £30 to £1095, male, and £545 by £25 to £795 by £30 to £945, female); or Scientist III (£445 by £25 to £845, male, and £420 by £20 to £720, female), according to qualifications and experience. London location allowance of £32 10s., rising to £78 per annum at the maximum of the scales, is payable in addition.

Write, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates), to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope TT/709. Original testimonials should not be forwarded. Closing date 28th December, 1953. E6271

CRAWLEY DEVELOPMENT CORPORATION

CRAWLEY NEW TOWN

SCIENTIFIC OFFICER AND TECHNICAL ASSISTANT (CHEMIST)

Crawley Development Corporation require for duty at their Sewage Treatment Works:

(a) SCIENTIFIC OFFICER. Salary scale £630 to £850 per annum. Applicants should possess Degree in Chemistry or hold qualification F.R.I.C. having passed examination for Fellowship in Branch I. Candidates must have practical experience in water treatment and the physical, chemical and bacteriological examination of water supplies.

(b) TECHNICAL ASSISTANT (CHEMIST). Salary scale £350 to £465 per annum. Applicants to be experienced in chemical analysis of sewages and trade effluents and possess qualification in chemistry and A.M.Inst.S.P.

For both appointments placing within salary scale will depend upon qualifications and experience. Contributory superannuation.

Application forms from Chief Engineer, Broadfield, Crawley, Sussex, should be returned by 19th December, 1953.

E6284 C. A. C. TURNER, Chief Executive.

MINISTRY OF WORKS

NEW ZEALAND

VACANCY FOR ENGINEER, HYDRO INVESTIGATION

Applications are invited for position of ENGINEER, Hydro Design Section, Ministry of Works, Wellington. Applicants should hold recognised Engineering Degree, and be registered or chartered engineers.

Minimum commencing salary £920 (N.Z.) yearly, advancing by annual increments of £50 (N.Z.) to £1180 (N.Z.), subject to satisfactory performance of duties.

Duties include investigation and analysis of hydrological data pertaining to hydro-electric development schemes, investigation of sites, &c.

Application forms and further information concerning conditions of appointment obtainable from The High Commissioner for New Zealand, 415, Strand, London, W.C.2, mentioning this paper and quoting reference 3/74/91.

Closing date 31st December, 1953. E6321

BRITISH TRANSPORT COMMISSION

ENGINEERING LABORATORY OF THE RESEARCH DEPARTMENT

SCIENTIFIC OFFICER, GRADE I

A vacancy exists in the Engineering Laboratory of the Research Department at Ashford, Kent, for a SCIENTIFIC OFFICER, Grade 1. Salary range £778/850 per annum. Professional/academic qualifications essential, together with experience of experimental work in mechanical engineering.

Superannuation scheme and certain travel facilities. —Applications to Director of Research, 222, Marylebone Road, London, N.W.1. E6288

LONDON COUNTY COUNCIL

ASST. ENGINEER-IN-CHARGE

ASST. ENGINEER-IN-CHARGE required at the County Hall, S.E.1, with experience in running and maintenance of steam boilers and auxiliaries, kitchen, ventilating and air-conditioning plant, central heating and hot water supply systems, water softening plant. Some experience of D.C. and A.C. electric motors, electric lifts and lighting and refrigerating plant an advantage. Salary £625 by £30 to £685.—Application form from Chief Engineer (53/39), London County Council, County Hall, S.E.1, returnable within next 14 days. (Enclose S.A.E.) (1304.) E6316

PUBLIC APPOINTMENTS

SOUTH DEVON WATER BOARD

AVON DAM

RESIDENT ENGINEER

Applications are invited for the appointment of RESIDENT ENGINEER to supervise, under the consulting engineers, the construction of an impounding reservoir on the River Avon, near South Brent, Devon. The works comprise a concrete gravity dam with a length of about 860ft and a maximum height of about 100ft above river level, together with valve tower, spillway, gauging bay and ancillary works. It is expected that work will commence in April, 1954, and will take at least three years to complete.

Applicants must be Corporate Members of the Institution of Civil Engineers and have had previous experience in this class of work.

The salary will be £1500 per annum, rising by annual increments of £100 to a maximum of £1700 per annum. The Resident Engineer will also receive a living allowance of £200 per annum and an allowance for a car in accordance with the National Joint Council Scale. The appointment is to be terminable by three months' notice on either side.

The successful applicant is expected to make his own arrangements for housing accommodation which should be as close to the works as is reasonably practicable.

Applications, giving full details of age, qualifications and experience, together with the names and addresses of at least two persons to whom reference might be made, are to be sent to the Board's Consulting Engineers, Messrs. Lemon and Blizard, 5, Tufton Street, Westminster, London, S.W.1, not later than 1st January, 1954.

F. BROWN,
Clerk of the Board.

Churston House,
Kingsbridge, Devon,
26th November, 1953. E6279

SOUTHEND-ON-SEA HOSPITAL MANAGEMENT COMMITTEE

ASSISTANT ENGINEER

Applications are invited for the post of ASSISTANT ENGINEER at this Hospital Group under the direction of the Group Engineer. Salary in accordance with Whitley Council Professional and Technical Council "B," viz., £475 by £15 to £555. The appointment is subject to National Health Service (Superannuation) Regulations, 1950. The successful candidate will be required to pass satisfactorily a medical examination.

Candidates must have served a recognised engineering apprenticeship, preferably holding a First Class Board of Trade Certificate of Competency in Marine Engineering or equivalent Naval Certificate, had sound experience in the maintenance and operation of steam and diesel power plant, generating alternating current electricity.

A modern semi-detached bungalow is available for which a rent will be charged.

Applications, stating age, education, professional training, qualifications and experience, and accompanied by copies only of two recent testimonials and the names and addresses of two professional referees, to be sent to the Group Engineer, Management Committee Offices, General Hospital, Rochford, Essex, by the 11th December, 1953.

J. C. FIELD,
E6277 Secretary.

SOUTH ESSEX WATERWORKS COMPANY

APPOINTMENT OF DEPUTY CHIEF ENGINEER

Applications are invited for the above appointment at a commencing salary of £1600 per annum.

Applicants should possess a sound knowledge of waterworks practice and the operation of works of some magnitude, also administrative ability. Experience of abstraction, storage and treatment of river water would be of value.

Candidates should be Corporate Members of the Institution of Civil Engineers and not more than 45 years of age. The appointment (which will be terminable by three months' notice on either side) will be subject to admission to the company's contributory superannuation scheme (details of which are available) and a satisfactory medical report.

Applications, endorsed "Deputy Chief Engineer," stating age, qualifications and experience, accompanied by copies of three recent testimonials and the names and addresses of three persons to whom reference may be made, should be sent to the undersigned not later than 31st December, 1953.

HUGH G. RAMSAY, M.I.C.E.,
Chief Engineer.

342, South Street,
Romford, Essex. E6293

MINISTRY OF WORKS

HEATING AND VENTILATING DRAUGHTSMEN

HEATING and VENTILATING DRAUGHTSMEN required in London with experience in design of all types of heating and/or ventilating systems and general domestic engineering installations for all classes of buildings.

Salary range £396–£628. Starting rate according to age, qualifications and experience. Promotion and pension prospects.

Applicants should have British nationality, technical standard of O.N.C. or equivalent, and apprenticeship or suitable practical experience of at least three years, including one year in a drawing-office.

Apply, giving age and full details of training and experience, to WG10/CE7 (M), Ministry of Works, Abell House, John Islip Street, London, S.W.1. E6283

THE ENGINEER

DECEMBER 4, 1953

Centenary of the Society of Engineers

THE Society of Engineers, whose membership includes those engaged in all branches of engineering, is making preparations for the celebration of its centenary next year. The Society was founded in London in 1854 as the Putney Club to provide opportunities for the reunion of engineers who had been educated at Putney College. The present title of the Society was assumed in 1857. In 1910, there was an amalgamation with the Civil and Mechanical Engineers' Society, which had been formed in 1859, and since then the official title has been the Society of Engineers (Incorporated). During the centenary year, Mr. W. R. Howard will occupy the presidential chair. He joined the Society in 1917, was elected a fellow in 1946, and has been honorary treasurer since 1947. The centenary celebrations will begin on May 4th next with a conversazione at the Science Museum, South Kensington. On the following day, there is to be a meeting for the presentation of papers dealing with the progress of civil, mechanical, electrical and aeronautical engineering during the last 100 years. This will be held in the Geological Society's Rooms at Burlington House, Piccadilly, London, where the ordinary meetings of the Society regularly take place. Another event in the programme is a trip on the River Thames to visit the works of the Lafarge Aluminous Cement Company, Ltd., at West Thurrock, and the celebrations in London will end with a banquet in the Fishmongers' Hall, near London Bridge. Scottish members of the Society are to hold a centenary banquet on May 15th at the headquarters of the Royal Society of Edinburgh. The Society's Australian division is also arranging appropriate celebrations. The divisional president is Emeritus Professor Sir Henry Barraclough, formerly Dean of the Faculty of Engineering of Sydney University.

Technological Education Conference

LAST Friday, a private conference was held at Grosvenor House, London, attended by directors of the forty research associations in this country and members of the Advisory Council for Scientific and Industrial Research. Its purpose was to consider the problems of the education of technologists and technicians, and to examine in what manner the research associations can continue to assist. The research associations lying between the universities and technical colleges, on the one hand, and industry on the other, hold a particularly important place in the training schedule and it was thought that their influence could be increasingly exploited. It was discussed how the relations between these two parties could be improved and collaboration made more effective. The younger staff of the associations are already encouraged to continue their own education, and one of their most valuable functions is to provide special opportunities to graduates before entering industry to obtain experience in the technology of his particular industry which he could get nowhere else. The associations also encourage students to work in the laboratories during vacations and they provide courses of instruction for staffs of technical colleges or member firms. Provision is also made for conferences and summer schools and member firms are sending their own staffs to work at the associations themselves. Sir Ian Heilbron, F.R.S., chairman of the Advisory Council, speaking at a luncheon during the conference, stressed the need for industry to embrace more earnestly the research work undertaken in this country and he commented on the lack of financial support from several sections of industry. He declared also that not enough engineers and scientists were admitted to the board rooms of industry. Lord Woolton, C.H., in the absence of the Lord President, Lord Salisbury, remarked that whilst he did not minimise the very important work of the technical schools, it was their task to produce the non-commissioned officers. For the other offices of the profession he maintained that only the university provided the right basis.

Future of the British Industries Fair

LAST year the Board of Trade's exhibitions advisory committee appointed a sub-committee to review the existing arrangements for the British Industries Fair. Sir Ernest Goodale was the chairman of the sub-committee, the report of which has now been published as a White Paper. In the report the sub-committee urges that the B.I.F. should continue annually and that its primary purpose should be to promote trade at home as well as overseas. The sub-committee's view is that the B.I.F. is more than a trade fair ; it should project British industry on the world, the report says, and be a pageant of the best in British industry. The sub-committee does not agree with the recommendation of the Ramsden committee that the whole of the Fair should ultimately be concentrated in one centre in London. It says that the Birmingham section, which has its own suitable permanent building, has grown and developed into a large and self-supporting and separate section which at present covers twenty-five acres of exhibiting space. The sub-committee states, therefore, that the Birmingham section should remain where it is. About the London section of the Fair, however, the sub-committee says that, subject to the right kind of buildings being erected, the Crystal Palace would be a satisfactory location. But, it is added, there is no justification, in present economic conditions, for recommending the Government alone to undertake capital expenditure solely for a permanent home for the London section of the Fair on the scale that would be needed. The report sets out, in conclusion, the sub-committee's recommendations for the establishment of a public corporation to take over from the Board of Trade responsibility for the B.I.F. from 1955.

Collision at Irk Valley Junction

THE Ministry of Transport and Civil Aviation report has now been issued on the inquiry into the accident which occurred at 7.40 a.m. on August 15th last at Irk Valley Junction. This junction is situated on a viaduct on the electric line between Manchester Victoria and Bury. In the accident an up electric passenger train collided with a down steam passenger train on the diamond crossing of the junction. The up electric train from Bury to Manchester ran past the junction home signal at danger at a speed of about 35 miles an hour. The steam train from Manchester to Bacup was passing under clear signals over the junction to the branch line at about 10 miles an hour. The leading electric coach struck and overturned the steam engine, smashed through the parapet wall of the viaduct and fell on to the bank of the River Irk below. As a result of the accident nine passengers and the driver of the electric train were killed and fifty-eight passengers were injured, twenty-two severely. Following his inquiry into the accident the inspecting officer, Colonel D. McMullen, came to the conclusion that there were two contributory causes. First, the driver of the electric train ran past the home signal at danger, and, secondly, a signalman committed a serious irregularity in permitting the steam train to pass over the junction to the branch line after he had given the " line clear " for the electric train.

Road Modernisation

ON Friday last, the House of Commons debated a motion concerning the modernisation of this country's road system. Mr. G. A. Pargiter, who introduced the motion, claimed that as the roads now carried over 70 per cent of all inland goods transport, their modernisation was essential to ensure maximum industrial and agricultural productivity. The motion pointed out that the economic loss alone from road accidents was estimated at £150,000,000 a year, and the Government was urged to consider making available adequate grants to local authorities so that they could overtake rapidly arrears of road maintenance. Mr. Hugh Molson, Joint Parliamentary Secretary to the Ministry of Transport, replied to some of the points raised during the debate. In the course of his speech he recalled that the motion urged that priority should be given to the completion of projects which, in most cases, had been started before the war and had then been abandoned. Where capital had already been sunk in road improvements it was obviously economical to finish the job. Unfortunately, however, even the completion of projects which have been held up would cost £20,000,000, and a careful estimate had therefore to be made even in dealing with the uncompleted jobs. During the current financial year, Mr. Molson explained, the total estimate granted to the Ministry of Transport for roads was £5,000,000 on major improvements and £26,200,000 on minor improvements and maintenance. Last year, he added, the Minister had given very careful consideration to the way in which he could best spread the limited money made available to him, and was finally convinced that the inadequacy of size and design of the roads for dealing with a greatly increased volume of traffic was more serious than inadequate maintenance.

Inventions and Designs

IN a letter published in *The Times* on Monday last, Mr. P. E. Lincroft, secretary of the Chartered Institute of Patent Agents, sets out the Institute's views on the Inventions and Designs (Crown Use) Bill, the second reading of which was moved in the House of Lords on Tuesday. The Institute's opinion, as expressed in Mr. Lincroft's letter, is that the Bill seeks to place on a permanent basis, in modified form, certain emergency provisions relating to inventions and designs which may have " more far-reaching effects than would be apparent at first sight." In particular, Mr. Lincroft refers to Clause 3 of the Bill, which, he says, would appear to give to certain Government departments almost unlimited powers to extort industrial information from any individual person or firm in this country who has developed any manufacture, process or technique. In the opinion of the Chartered Institute of Patent Agents, the powers which would be given by the Bill to the Ministry of Supply and the Admiralty, necessary though they may be for the defence of the country in any sufficiently grave national emergency, should never be incorporated as part of the permanent law of the realm. It is thought that, if the Bill becomes law, steps will be taken by many oversea firms (who tolerate the existing regulations on a temporary basis) to cancel or discontinue agreements for the exchange of information, and that much more reluctance will be shown to enter into such agreements in the future. The suggestion made in Mr. Lincroft's letter, therefore, is that further steps on the Bill should be delayed to enable some assessment to be made of the effect of the Bill on the industrial well-being of this country. On the motion of Lord Woolton, speaking for the Government, the debate last Tuesday was adjourned.

Measurement of L.F. Response of Servo-Mechanism Components

By E. J. P. LONG, B.Sc. (Eng.)*

The design and operation of an apparatus for producing a sinusoidal signal in the frequency range 0·5 c/s to 20 c/s, together with suitable equipment for measuring attenuation and phase shift at these frequencies, is described. The method is compared with others and the use of the instrument in measurements pertaining to the testing and development of components and closed cycle systems is illustrated.

IN engineering practice, a knowledge of the sub-audio frequency transmission characteristics of a system or component is often helpful in the design and development of equipment. In particular the achievement of stability in a closed loop control system may be reduced from intuitive trial to positive analysis by a judicious use of frequency response data. Components for which frequency response data are often desired may include mechanical devices such as hydraulic pumps and motors, pneumatically operated valves, control linkages and vibration dampers ; electrical devices such as transformers, filters, equalisers, electronic and magnetic amplifiers, or electro-mechanical devices such as a.c. and d.c. machines, single stroke motors, clutches, data and power transmitting repeaters.

It is in the marrying together of a number of such devices to form a system, satisfactory as regards cost, performance and simplicity, taking into account the components which are predetermined and the selection of those which are not, that the usefulness of making frequency measurements on them arises. The range of frequencies of interest in systems involving the use of such components as mentioned extends from less than 1 c/s to about 10 c/s to 20 c/s. Frequency response may be calculated with a degree of labour corresponding to the complexity of the defining equations. More often the values of the parameters necessary for calculation are not available or it is not possible to present a sufficiently accurate or simple mathematical relation between input and output quantities. Direct measurement is thus useful as a check, or in lieu, of calculations. Sometimes a complete system may not be available for test until all the heavy equipment has been erected on site. In such cases analogues in the form of electric circuit elements may be evolved upon which measurements can be made.

The Nature of the Measured Response

If a machine has input and output shafts connected by a fixed reduction gear, the ratio of the shaft motions is independent of the nature of the motion imparted to the input shaft. Thus, if a sinusoidal oscillatory motion is given to the input shaft, the motion of the output shaft will be a reduced replica, reaching a maximum displacement at the same instant as the input, irrespective of the frequency of motion. Consider an input shaft controlling, say, the field regulator of a d.c. generator while the output shaft is that of a motor supplied from the generator. In this case there are time lags in the system due to the field inductance of the generator and the mechanical inertia of the motor. If the system has linear dependence of one quantity on another the motor shaft will reproduce the sinusoidal motion of the field regulator shaft, but with relative amplitude and phase lag dependent on the frequency of oscillation.

If we can calculate or measure the relative amplitude and phase of input and output quantities over a range of frequencies from zero to infinity the performance of any linear device is completely determined. For example, the response of a system or component to a sudden change in the input quantity, i.e. the transient response, could be calculated from a knowledge of the frequency response. While the transient response may form part of the performance specification of an apparatus, this response does not in itself disclose the effects of individual system parameters, nor is the transient response of the whole the sum of the responses of the components. Measurement of frequency response, although an indirect method, rapidly yields the effects of variation of individual parameters and the frequency response of the whole may be readily obtained from the response of the components.

Specification of a Measuring Apparatus

A frequency response test on a system or component consists of varying the input sinusoidally and measuring the relative phase and amplitude of the output over a suitable range. The range of frequencies often suitable in electro-mechanical systems may be 0·5 c/s to 20 c/s. Any testing apparatus should be capable of generating a sine wave of pure form and constant amplitude over this frequency range or greater, have an accurate indicator of frequency and enable readings of phase shift and amplitude to be made on directly calibrated dials. Moreover, a visual indication of the actual input and output wave forms of the apparatus under test has a value which can only be fully appreciated as a result of experience.

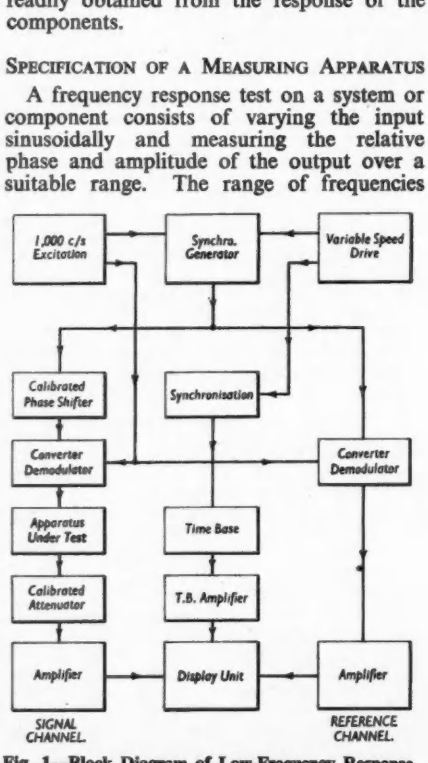

Fig. 1—Block Diagram of Low-Frequency Response Measuring Apparatus

Principle of Operation

An apparatus which has given satisfactory service over the last four years is described below. The method adopted consists of continuously revolving the rotor of a synchro generator (i.e. Admiralty-type transmitter magslip) so that one complete revolution corresponds to one cycle of the low frequency which it is desired to generate. The rotating magslip acts as a mechanical modulator to a high-frequency carrier signal separately generated. This method carries with it inherently an extremely simple and accurate method of measuring phase shift. By interposing a differential synchro (i.e. follow-through magslip) between the generator synchro and a demodulator unit, it is possible to shift the phase of the test signal by displacement of the rotor of the differential synchro. The phase shift is strictly proportional to the rotor displacement which may be controlled by a dial calibrated directly in degrees. Various published works have since made reference to the basic principles involved, either in a review of possible methods (1) or in passing to other methods (2) or in applying the same principle in a different way (3). It is thought that the method here described has valuable advantages in respect of simplicity, accuracy, ease of use, cost and versatility.

A magslip or synchro of the kind considered here has a winding on both stator and rotor. The rotor is supplied at a fixed frequency of 1000 c/s, which may be derived from a small alternator or a valve oscillator. A 3in magslip requires about 10W at 20V. A valve oscillator is quite convenient. Slight frequency drift and distortion in the oscillator can be tolerated as it only generates what is, in effect, a carrier signal. As the rotor is displaced through 360 deg. the amplitude of the stator voltage varies sinusoidally.

If

f_c = frequency of the excitation of the rotor in cycles per second.

f_m = speed of rotation of rotor in revolutions per second.

m = modulation factor, i.e. amplitude varies between $\pm m$,

then

instantaneous value of stator voltage

$$= E_0 m \sin 2\pi f_c t \sin 2\pi f_m t.$$

If this signal is added to a constant amplitude signal from the same source as the rotor excitation, which will have the form $E_0 \sin 2\pi f_c t$, the signal has the form

Derived voltage

$$= E_0 m \sin 2\pi f_c t \sin 2\pi f_m t + E_0 \sin 2\pi f_c t.$$

$$= E_0 \sin 2\pi f_c t(1 + m \sin 2\pi f_m t).$$

This is the usual form of an amplitude-modulated wave which if $m<1$, can be demodulated to produce the desired low-frequency component. The unit in which the signals are combined and the demodulation performed is termed the converter demodulator.

It should be pointed out that the frequency range is not limited to that prescribed in the present apparatus since by control of both armature and field voltages of the motor driving the generating magslip a range of 100 : 1 or greater may be obtained which can be extended by the use of a multi-speed gearbox. The top frequency is limited by its relation to the carrier frequency.

Practical Form of the Apparatus

The layout of the apparatus in block form is shown in Fig. 1. The stator output voltage from the magslip generator is split into two

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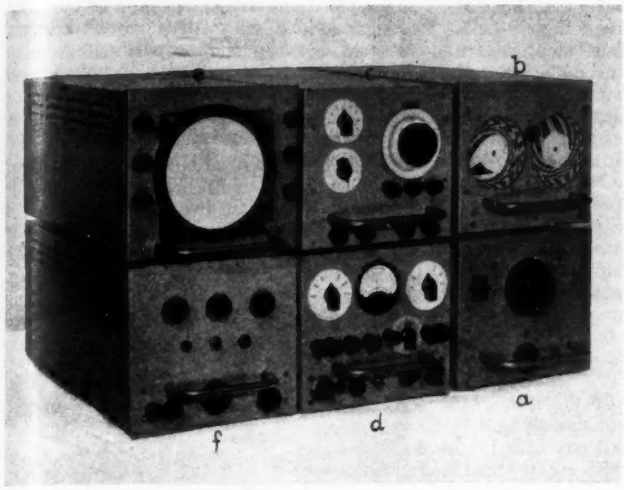


Fig. 2—L.F. Response Measuring Apparatus

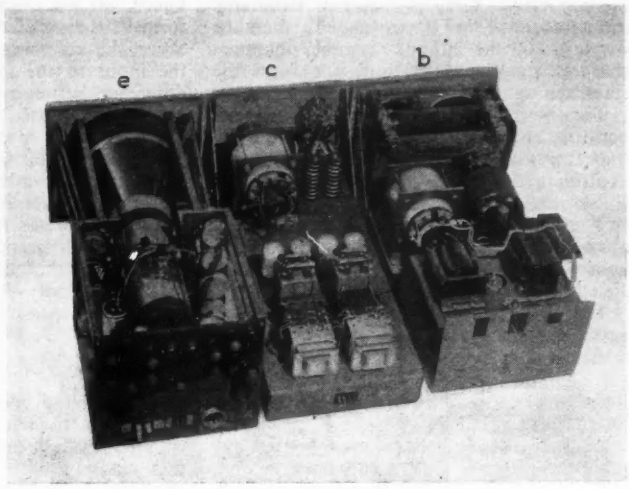


Fig. 3—Top Deck of Response Measuring Apparatus

channels. One of these is a reference channel which passes through a converter demodulator and direct-coupled amplifier units only, to one element of the two element cathode-ray tube display unit. The other channel passes through the follow-through magslip acting as a calibrated phase shifter before passing to a converter demodulator. The output from this unit is the low-frequency sine wave test signal. It is fed to the apparatus under test. The output from the test apparatus is fed to the second element of the cathode-ray tube via a calibrated attenuator and direct-coupled amplifier.

It is assumed that the apparatus under test will accept an electrical input and generate a corresponding electrical output. Electrical signals may, however, be converted to mechanical and vice versa by suitable elements. For clarity of display it is desirable that one complete cycle only of the input and output waveforms be displayed on the cathode-ray tube screen and that this cycle should be repeated exactly in superposition by successive rotations of the generating magslip. This result is ensured by a mechanical contact on the magslip drive which delivers one pulse per revolution to synchronise the time base producing the horizontal deflections of the twin beams in the cathode-ray tube.

The display end of the apparatus consists of a two-channel oscilloscope with direct-coupled amplifiers and a time base which may be externally synchronised. It should be remembered that in some cases the electrical input and output may be at different voltage levels and consequently the test equipment connected thereto must be electrically isolated. A case in point is a valve amplifier in which the input has one side at earth potential and the output is balanced about some potential above earth. If input and output are to be monitored on the same cathode-ray tube there should be no electrode such as a beam-splitting plate common to the two channels, which must themselves have individual power supplies. A cathode-ray tube with two separate gun assemblies is used in the present apparatus. When the reference channel is used, direct-voltage isolation may take place at the generating end since the common source is divided through transformers and the demodulators may assume any relative potential.

The external appearance of the complete apparatus is shown in the photograph, Fig. 2, and the internal construction in Figs. 3 and 4. Unit *a*, Figs. 2 and 4, houses the 1000 c/s fixed frequency valve oscillator for magslip excitation. The front panel has a control for setting the test frequency, i.e. magslip rotational speed. The exact frequency is set by a stroboscope on front panel of unit *b*, Fig. 2, which also contains the magslip, its drive and motor supplies and the control circuit for the neon tube which illuminates the stroboscopic discs at mains frequency. Twenty spot frequencies in the range 0·5 c/s to 20 c/s may be set with an accuracy depending on the frequency of the commercial a.c. mains. Consideration was given to controlling the speed of the magslip generator by a velocity servo (automatic speed regulator), but the accuracy of a stroboscopic method proved quite adequate for the job and is much simpler.

The phase shift and attenuator dials are seen on the panel of unit *c*, Fig. 2, while the two converter demodulators are visible on the chassis of *c*, Fig. 3, and the circuit diagram of this unit is given in Fig. 5. The circuitry of the oscillator, time base, amplifiers, and power supplies follow standard practice.[4] The two amplifiers housed in unit *d*, Fig. 4, provide balanced deflection voltages for the deflector plates of the cathode-ray tube elements, unit *e*. Panels of units *e* and *f*, Fig. 2, carry the oscilloscope controls while the high-voltage cathode-ray tube power supplies and time base are in unit *f*. The screen coating of the cathode-ray tube has an after-glow of five seconds so that the trace of a whole cycle remains visible even at the lowest test frequency generated.

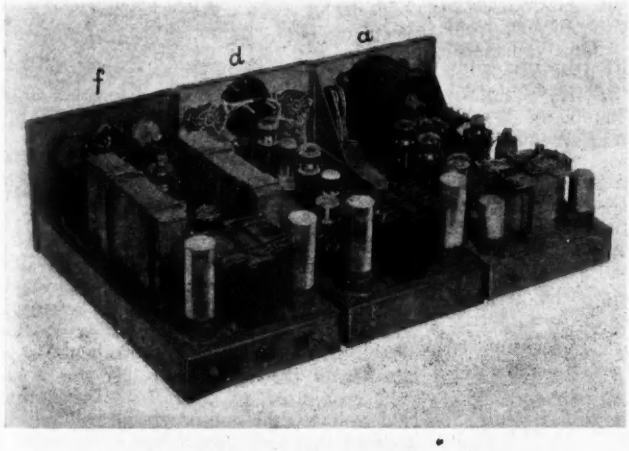
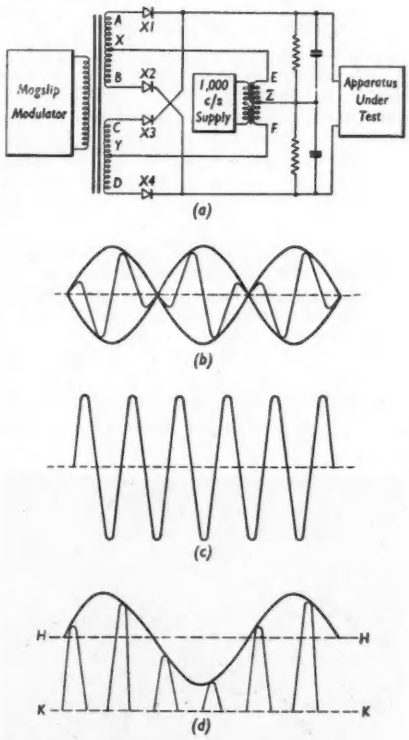


Fig. 4—Lower Deck of Response Measuring Apparatus

Method of Measurement

Referring to the block schematic diagram, Fig. 1, the test signal channel is set up in the absence of the apparatus under test, i.e. the output of the converter demodulator



(*a*) Circuit of converter demodulator unit.
(*b*) Waveform of voltage between points *XA* in diagram (*a*)
(*c*) Waveform of voltage between points *ZE* in diagram (*a*)
(*d*) Voltage *ZE* and *XA* combined and rectified by rectifier *X*1

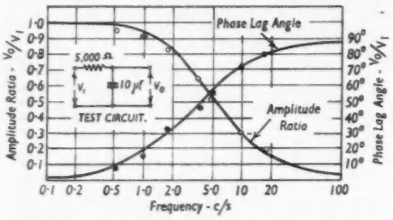
Voltage in (*d*) is of half wave rectified form, i.e. alternate half cycles are absent; they are supplied by voltage *ZF* and *YC* via rectifier *X*3. There remains a d.c. component, i.e. modulation is symmetrical about *HH* rather than *KK*. The d.c. component is eliminated by the action of the remaining branches, including rectifiers *X*2 and *X*4.

Fig. 5—Action of Converter Demodulator Unit

is connected directly to the calibrated attenuator. Two traces should then be displayed on the cathode-ray tube, one from the test signal channel and one from the reference signal channel.

The horizontal and vertical trace shift controls are adjusted until the axes of the two traces are coincident. A pre-set gain control in the reference channel is adjusted to set the trace height of the signal from this channel to 50mm. The calibrated attenuator in the test channel is used as a gain control to set the trace height of the signal from this channel to 50mm.

The two traces will now be symmetrical about the same axis and of similar height.



Full-line: calculated value. Circles: measured values.

Fig. 6—Comparison of Measured and Calculated Values of Phase Shift and Attenuation of Simple Circuit

The traces each consist of a single cycle of the low frequency test signal. The synchronisation is arranged so that the reference trace is maintained in a form similar to the larger traces, Figs. 7 and 11, i.e. with the start of the cycle coincident with the left-hand edge of the trace. The trace from the test channel will similarly be a single cycle but displaced in phase. The phase shift control is rotated until the two traces are coincident. It is convenient if the phase shift dial is mounted so that it is indicating zero when the traces are coincident. Coincidence of the traces is, of course, maintained irrespective of the frequency of the sinusoidal test signal.

The apparatus under test is now connected to the output of the converter demodulator, the channel connections remaining in the setting up condition. Any disturbance due to loading of the test signal source by the apparatus under test will be immediately apparent by the distortion of the trace on the cathode-ray tube screen. If such distortion occurs a direct-coupled amplifier with high input impedance and low output impedance must be inserted between the signal source and the apparatus under test.

The attenuator is then disconnected and the overall arrangement of Fig. 1 set up. The reference trace is unaltered. The second trace is now the output from the apparatus

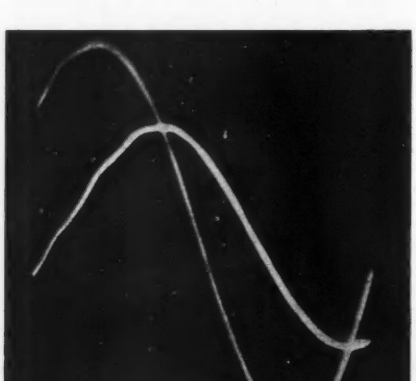


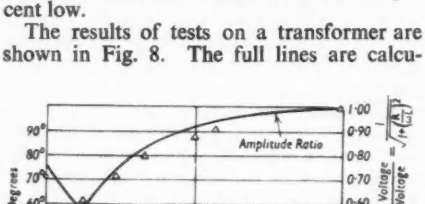
Fig. 7—Response of Resistance-Capacitance Network

under test and may, for example, have the form of the smaller traces in Figs. 7 or 11. Since the reference trace is identical with the input to the apparatus under test, the difference between the two traces now displayed represents the transmission characteristic of the apparatus under test at the particular frequency of the test signal. The calibrated attenuator and phase shift control are reset to restore the test signal trace to coincidence with the reference trace. The differences in the readings on the dials will be the attenuation and phase shift which a signal of the set frequency will undergo in passing through the network under test.

Measurements on Static Elements

The ultimate accuracy of the instrument depends on the diameter of the spot on the cathode-ray tube screen. It has been found that readings of phase shift are repeatable and accurate within ± 2 deg. A check may be made by measurements on a passive circuit with known characteristics. The calculated and measured results of such a test are shown in Fig. 6. The photographed oscillogram in Fig. 7 shows the input and output wave forms of this simple circuit when driven at 5 c/s. At this frequency the measured phase shift was 2 deg. below the calculated value and the attenuation 4 per cent low.

The results of tests on a transformer are shown in Fig. 8. The full lines are calcu-


Amplitude Ratio
Phase Shift
Θ = Phase Lag in Degrees
Output Voltage / Input Voltage = $\sqrt{\left(\frac{R}{\omega L}\right)^2+1}$
Amplitude Ratio = $\frac{R}{\omega L}$
Frequency - c/s

The curves drawn are the calculated responses. The measured points are denoted by △ for amplitude ratio and by ○ for phase shift. N.B.—Values at 100 c/s. taken with auxiliary oscillator.

$$\text{Tan } \theta = \frac{R}{\omega L}, \text{ where } R = \frac{n^2 R_1 R_2}{n^2 R_2 + R_1},$$

n = ratio of primary turns to secondary turns
R_1 = resistance of primary
R_2 = resistance of secondary
L = inductance of primary

Fig. 8—Low-Frequency Response of a Small Transformer

lated values and the isolated points the measured values. Here measurement is used to check the estimated values of the parameters used in calculating the frequency response.

Analogues of certain machines, devices, or complete systems may be formed from electrical circuits using only resistance, capacitance and inductance on the basis of the similarity in forms of the equations relating to the real and simulating devices. The equations are based on idealised assumptions. In particular relations between interdependent quantities are assumed to be linear.

The relation between input and output quantities of an element or cascaded group of elements may be expressed in complex form $R\hat{\angle}\hat{x}$ where the length R of a radius arm denotes the magnitude of the amplitude ratio and $\hat{x}$ the phase angle between the quantities. A commonly encountered idealised relation has the form

$$R = k/\sqrt{1+\omega^2 T^2}\ ;\ \hat{x} = \tan^{-1}(-\omega T),$$

where k and T are constants, and ω is 2π times the frequency of the input signal.

Such an idealised relation is often assumed to hold between the output voltage of a generator and the applied field voltage and between the speed of a motor and its applied armature voltage. When two or more devices are cascaded the overall output-input relation will be $R_1 . R_2 ; (\hat{x}_1 + \hat{x}_2)$. An analogue of a generator controlled motor may be formed by the first two circuits shown in Fig. 9. In the case of a generator and motor a phase lag is introduced at all frequencies. It is usually desired to reduce this lag. This may be accomplished by a cascading network which has considerable phase lead over the appropriate frequency range. Thus we may have three networks cascaded

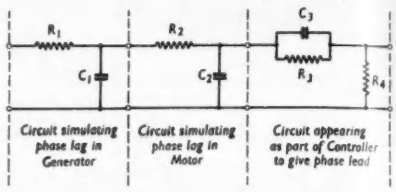


Fig. 9—Cascaded Circuits Simulating Machines and Controller

together as shown in Fig. 9, the first two to simulate electrical machines, the third being in the actual form it would take as part of a control amplifier. The overall output-input relation of the group is required in order to study the behaviour of a complete system into which the group may be incorporated. The calculated phase shifts of the network in Fig. 9 at a frequency of 1 c/s is 118 deg. The measured value determined by the apparatus was 122 deg., being the sum of 78 deg. lagging in the first network, 84 deg. lagging in the second and 40 deg. leading in the third network. The calculated overall amplitude ratio was 0·00117 and measured value 0·00119.

Measurements on an Electro-Mechanical System

A typical electrical speed control system shown diagrammatically in Fig. 10 consists of a chain of elements. Control of the shaft speed of a normal shunt wound d.c. motor below its rated speed may be attained by varying the armature voltage with the field excitation held constant. This variable voltage is often obtained from a d.c. generator on which the only load is the motor. The generator is driven at constant speed and has its field voltage controlled, thus varying the generated voltage and the motor speed. Such a combination forms the well-known Ward Leonard system of speed

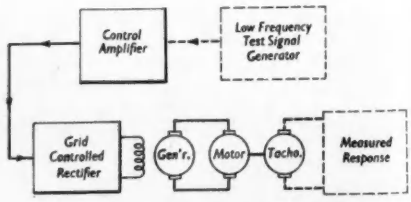


Fig. 10—Testing Cascaded Elements

control. Now if the speed of the motor shaft, monitored by a tachometer which generates a voltage proportional to the actual instantaneous speed, is compared with a reference voltage, setting a desired speed level, the difference between the two voltages is a measure of the speed error. If this error voltage is used to control the generator field voltage, the motor speed will adjust itself so that the speed error is minimised. Such a system is a common example of closed

loop continuous control system. In studying the stability of such a system we wish to measure the frequency response of various components or groups of components.

In the photographed oscillogram, Fig. 11, the thin trace shows the input to the field control amplifier of such a system, while the thick wavy line is the tachometer voltage. It is seen that the sinusoidal form is preserved through five stages, namely, control amplifier, grid-controlled rectifier supplying the generator field, the armature current of the

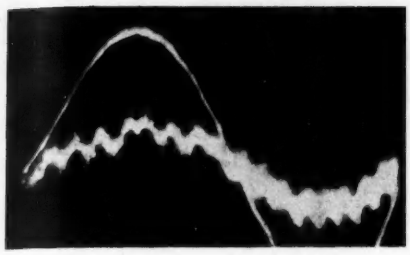
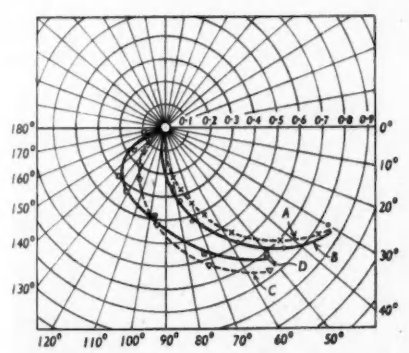


Fig. 11—Tachometer Voltage Waveform

generator and motor, motor shaft displacement and the tachometer generated voltage. It is likely that the range of linear interdependence of quantities is limited in every one of these stages, so it is essential that the actual input and output wave forms should be displayed for examination.

The results of tests made with the instrument on such a system are shown plotted in Fig. 12. Curve *B* is the measured vector relation between generator armature voltage and its field voltage. Curve *D* is the measured overall vector relation between the tachometer voltage and the generator field voltage. Such loci are often calculated from a knowledge of machine constants and defining dynamic equations. Such calculated curves are shown as *A* and *C* in Fig. 12, corresponding to the measured curve *B* and *D* respectively. The differences thus shown are not inaccuracies in measurement, but are due to differences between the assumed values of parameters and the actual values under the particular working conditions. The



A and *B*, relation between armature voltage and field voltage of generator, Fig. 10.
A, theoretical.
B, measured.
C and *D*, overall relation between tachometer voltage and generator field voltage, Fig. 10.
C, theoretical.
D, measured.

Fig. 12—Theoretical and Measured Frequency Responses of Systems

parameters involved are generator field inductance, generator voltage coefficient, i.e. generated voltage per unit field, motor torque coefficient, i.e. torque per unit armature current, and motor back-e.m.f. coefficient—that is, voltage per unit velocity. These relations in actual practice deviate somewhat from linearity over the working range. Thus, whenever possible, it is desirable to make actual response measurements rather than to rely on calculations made with constants, the values of which are difficult to assess.

Sometimes the distortion of output wave forms such as the one shown in Fig. 11 is filtered out before being presented on the screen of the cathode-ray tube. If the filter has frequency-dependent characteristics in the band of frequencies being examined, these may be measured in the usual way and subtracted from the overall response measured when the filter is cascaded with the apparatus under test. Alternatively, a similar filter may be connected in the reference channel provided that the characteristics of the filters as connected in the two channels are identical.

Comparison with Other Methods of Measurement

An all-electronic method of generation and measurement has been described.[5] A resistance-capacitance oscillator directly generates the low-frequency sine waves, the frequency of which may be set in discrete values of 0·1 c/s from 0·1 c/s to 11 c/s. The accuracy of wave form and frequency of such generators depends on their stability after initial alignment. In the apparatus described,[5] the signal is presented as a circular trace on a cathode-ray tube. The radius of the circle is a measure of the amplitude. A bright spot is caused to occur in the trace when the sine wave is passing through zero, by which phase shift may be indicated. Such methods in which wave forms and phase shifts are synthesised may not be so attractive at low frequencies as rotational electric devices in which these functions are inherent, accurate and stable.

Rocking the rotor of a synchro generator as opposed to rotating it is a possible method.[6] A Scotch yoke mechanism actuates the rotor, thus producing an amplitude-modulated output feeding directly to the apparatus under test which must be a servo system to which this form of signal is acceptable, and having an output shaft driving a second synchro generator. A moving contact on the drive gear is rotated until points of maximum modulation of the two synchro output waveforms as indicated by a valve voltmeter coincide, the shift of the contact being the phase angle. This method is of limited application, both in the form of system with which it may be used and in the mechanics of the generating mechanism.

A similar mechanical oscillator combined with optical phase measurement has been used to test data transmitting elements.[7] Sinusoidal oscillatory motion is imparted to the rotor of the element by a motor-driven yoke and pulley system. Frequency is monitored by a tachometer. Phase is measured by the use of a photocell mounted above the unit under test. Pulses derived from the test unit and an adjustable arm on the mechanical generator are synchronised using an oscilloscope. This apparatus is of limited application and must be precision built since the phasing device is part of the equipment itself rather than a built-in precision component.

An apparatus using similar principles to the equipment described in this article has recently been described.[3] A dynamometer is used as a phase indicator. If a pure input current is applied to the fixed coils of a dynamometer element then the deflection of the associated moving coils may be made proportional to the phase difference of only the fundamental of the corresponding output current which is passed through the moving coils. This is useful when dealing with distorted output quantities, but a large amount of equipment is needed. Four separate channels with demodulators and drive amplifiers as well as the specialised and expensive indicator itself are required. Moreover, the amplitude has to be measured in the usual manner, except that in the apparatus described no provision was made for displaying the waveform on a time base, but only as a vertical line of which the height was held constant.

A low-frequency source of considerable power is found in the frequency converter.[2] This is a specialised machine of the Schrage motor class in which the brush position may be made a measure of phase angle. There are difficulties in measurement because of loading and non-uniformities, although they may be reduced at the cost of complexity. A power source may be obtained from the present apparatus by feeding the demodulated sine wave into the control amplifier supplying a generator field and using the armature voltage as the source. Any frequency dependence may be measured and subtracted from overall measurements. Similarly, if a powerful mechanical motion is required the control amplifier may directly control the field or armature of a motor. The same machine can probably be used either as generator or motor.

Thus we have available from the present apparatus and accessories four kinds of low-frequency signal: (1) direct from magslip to feed into position control system requiring this type of signal; (2) pure fundamental from the demodulator; (3) electrical power from a controlled machine as a generator, and (4) mechanical power from a machine controlled as a motor.

Results of measurement made with such equipments as described are helpful in the testing and development of components and promoting a better understanding of the equality of importance of the smallest and largest elements in system engineering, as, for example, in electrical systems, between heavy current and light current components.

References

[1] G. A. Korn and T. M. Korn: "Modern Servomechanism Testers," *Electrical Engineering*, N.Y., Vol. 69, September, 1950, page 814.

[2] and [3] D. Morris: "A Phase-Calibrated Variable Frequency Supply for the Testing of Servo-Mechanisms," *Proc. I.E.E.*, Vol. 97, Part II, February, 1950, page 37.

[4] and [5] D. O. Burns and C. W. Cooper: "A Harmonic Response Testing Equipment for Linear Systems," *Proc. I.E.E.*, Vol. 100, Part II, 1953 (to be published).

[4] E. Gilson: "A Versatile Oscilloscope," *Electronics*, Vol. 14, December, 1941.

[5] J. E. Bryden: "A Transmission Measuring Set for 0·1 to 11 c/s," *Electronic Engineering*, Vol. XIX, March, 1947.

[6] H. I. Tarpley: "An Instrument to Measure Servo-Mechanism Performance," *Review of Scientific Instruments*, Vol. 18, January, 1947.

[7] E. Marchant and A. Robb: "Methods of Testing Small Servo-Mechanism and Data Transmission Systems," *Journal I.E.E.*, Vol. 94, Part IIIa, 1947.

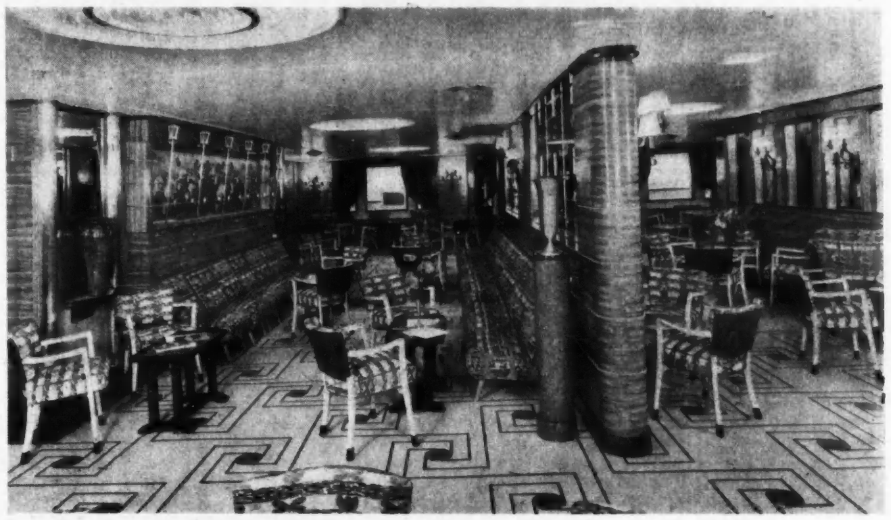
Exhibition Hall for International Fair, Marseilles

A NEW hall, of modern design, was recently erected for the International Fair at Marseilles, designed by the architects Lajarrige and Poutu, near the ancient hall. It is founded on 200 cast in situ piles, each of some 65 tons bearing capacity. The hall covers an area of 86,000 square feet and its interest from the engineer's point of view lies chiefly in the roof, since the contract required a free inside space of 310ft by 180ft. The roof is carried on a steel frame consisting of ten symmetrical trusses. These trusses rest on six main lattice truss steel girders 180ft long, resting on reinforced concrete columns. The roof is covered with corrugated asbestos cement tiles. The main lattice girders, weighing 15 tons each, were assembled on the site. The weight of the structural steelwork amounted to 250 tons. The hall was erected by the Entreprise Terrier.

GREEK LINE STEAMSHIP "OLYMPIA"

First-Class Lounge

Tourist Dining Room



Tourist Lounge

Tourist Cocktail Bar

Greek Line Steamship "Olympia"

No. I

In October the steamship "Olympia" sailed on her maiden voyage in the service of the Greek Line between Bremerhaven and New York. The ship is mainly designed to carry tourist-class passengers and is propelled at a service speed of 21 knots by twin screws. Power is provided by two sets of double reduction geared turbines developing 24,000 s.h.p. and taking steam at 525 lb per square inch pressure and 800 deg. Fah.

AFTER completing a pre-maiden voyage cruise from the Clyde to Southampton, during the course of which calls were made at Belfast, Liverpool and Dublin, the steamship "Olympia" sailed from Southampton on Tuesday, October 20th, on her maiden voyage across the North Atlantic. The service, which has been maintained by the "Neptunia" during the last three years, links Bremerhaven and New York, the ship making calls at Southampton, Cherbourg, Cobh and Halifax, on the westward run, with an additional call at Boston on the return eastwards, and the round voyage is expected to take twenty-one days. The "Olympia," a twin-screw turbine-driven ship, carries first and tourist-class passengers and was built and engined by Alexander Stephen and Sons, Ltd., at Linthouse, for the Greek Line.

Only a limited number of first-class passengers are carried, the ship being primarily intended to cater for tourist travel, and to that end considerable thought has been given in the design to provide a high degree of comfort for the tourist passengers. The photographs which we reproduce illustrate some of the public rooms on the ship.

It will be seen from the accompanying illustration that the new liner, which is the largest ever built for Greece, with her fine lines and white-painted hull, presents an excellent profile, which is well balanced and includes a soft-nosed raked stem, cruiser stern, a well-rounded bridge front, two tripod masts and a single large streamlined funnel. This funnel has been designed and wind tunnel tested with a view to keeping the deck free from smuts and funnel gases. The funnel has a height of 43ft 9in by 25ft 8in maximum width, and a length of 44ft at the deck. It is constructed of "Birmabright" aluminium alloy and consists of 6 S.W.G. plating carried on 4½in by 3in by ⅜in ordinary angle stiffeners and cross bracing.

Ship Particulars

Construction of the ship has been carried out under the survey of Lloyd's Register of Shipping and conforms with the regulations for the highest class of that society. She embodies in her design and arrangements all the recommendations of the Ministry of Transport and also the latest regulations for safety of life at sea, as agreed at the 1948 International Convention. Arc welding has been extensively used in the construction of the ship, the shell having welded butts and riveted seams, while riveting has also been employed as a method of fastening the frames and beams within the main hull. The superstructure is mostly welded, although at certain points riveting has been used, and prefabrication of units up to 35 tons in weight on the ground has been widely adopted.

There are three continuous steel decks and two partial steel decks within the main hull, while the upper deck extends for practically the whole length of the ship, and above this are the promenade sun and sports decks forming the superstructure. Of the total of nine decks, seven accommodate the passengers and crew and the arrangements of the spaces are in accord with present-day ideas of comfort, while an adequate area of deck is allocated for the leisure and recreation of the passengers.

Dimensions

Length overall	612ft
Length between perpendiculars	560ft
Breadth moulded	79ft
Depth moulded to "A" main deck	47ft
Load draught	28ft
Displacement	22,100 tons
Gross tonnage	23,000 tons
Service speed, knots	21

Accommodation

First-class passengers	140
First-class and tourist-class interchangeable	87
Tourist-class passengers	1071
Crew	341

Propelling Machinery

Type: Twin-screw, double reduction geared Parsons turbines of Pametrada design
Normal power: 24,000 s.h.p. at 140 propeller r.p.m.
Overload power: 25,000 s.h.p.
Steam supply: 525 lb per square inch gauge, 800 deg. Fah.
Boilers: Four of Foster Wheeler design, including two with controlled superheat and two of "D" pattern

Electrical Machinery

Type of generators: Five W. H. Allen generators, each driven by an eight-cylinder British Polar diesel engine
Rating: 600kW, 220V d.c.
Emergency: W. H. Allen generator, driven by a National Gas and Oil Engine Company's diesel engine
Rating: 100kW, 220V d.c.

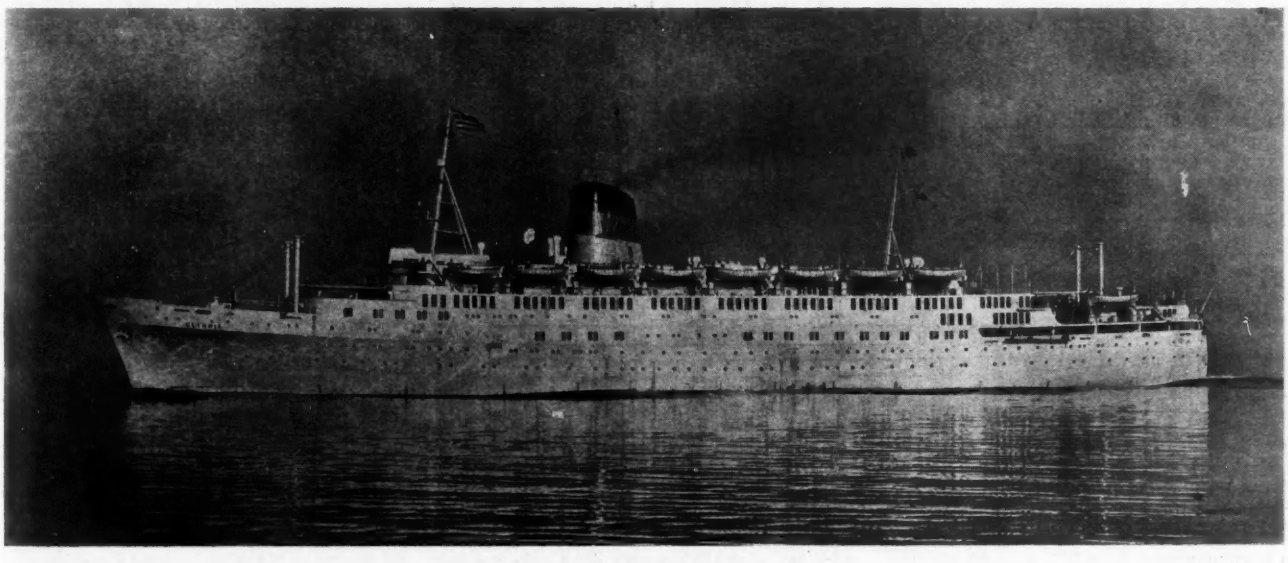
First-Class Accommodation

There are a number of single and two-berth cabins on the sun deck, including a few arranged as a private suite, and also two-berth cabins with a Pullman berth on the promenade deck. All have a private toilet and shower attached, and the decoration has been the responsibility of the shipbuilders. Part of the sports deck forms a promenade and there is a sunbathing space on the top of one of the deckhouses, while most of the promenade deck is available for the first-class passengers. The sun deck is mainly set aside as a recreation space, and at the aft end is the "Ægean" swimming pool, which is protected by glazed screens and has tables and chairs set out in the enclosed deck space, which forms a solarium. Immediately aft is the "Olympic" gymnasium, with "Neverland," the children's room to starboard, which opens on to the children's open-air play pen. Double swing doors and sliding windows at the forward end of the solarium open to the "Ægean Club" cocktail bar, which has wing alcoves arranged with pleasing effect to port and starboard, at a lower level than the main room.

Access to the lounge, which is forward on the promenade deck and is known as the "Mycenæan Room," is by short passages to port and starboard leading from the combined entrance hall and shopping centre, "Agora," which is panelled in Indian white mahogany and zebrano. In the lounge, sycamore, banded in dark oyster, is used for the panelling, and the scheme of decoration is based on an ancient Greek theme and includes a painting of the Mycenæan bull. Acoustic tiles are fitted to the deckhead and the furniture is arranged informally around a small dance floor, while a musicians' alcove is arranged at the forward end of the space. Aft on the same deck is the library and writing room, with its painting of London, and panelled in old English oak. Closely adjoining is the air-conditioned cinema, panelled in red leather, which can seat about 300 passengers, 200 in the auditorium on the upper deck and 100 on the balcony, which is arranged at promenade deck level. There are two air-conditioned dining rooms on the main deck, which are entered from a small hall linked by a stairway and a lift with the upper, promenade and sun decks. The room to port has a seating capacity of ninety at tables for two or four and the smaller room to starboard can seat forty-two passengers.

Tourist Accommodation

As already noted, the ship carries mainly tourist-class passengers, and they are accommodated in two, three, and four-berth cabins and a number of party cabins. A large proportion of the cabins have private toilets and showers



Steamship "Olympia"

attached and the cabins are situated on the upper, main, "A," "B," and "C" decks. At the forward end of the upper deck a lounge and dancing space, known as the "Zebra" room, which has raised galleries at each side, divided up into alcoves so as to form an intimate grouping of chairs and tables. The main decoration is a painting representing modern music makers, and the panelling is mainly in mountain ash veneer, while the musicians' alcove has a red oyster-coloured background. Forward to starboard is "Almacks," which is arranged as a card room with period furniture and paintings of sixteenth century and modern court cards. To port is the drawing room, which is panelled in old oak, furnished with period furniture, and on the walls is a painting of an English river scene.

Right aft on the same deck is the winter garden, which is fitted and decorated in the style of a summer house with painted tubular furniture, painted stone walls with trellis decoration, and a glazed roof giving a garden effect. Adjoining is the "Pavilion" dance space, which has folding and sliding Esavian screens at the aft end, while right aft is the gymnasium and children's room and play pen. On the deck over is the "Atlantic Bar," which overlooks the Atlantic swimming pool.

Another group of public rooms are to be found on the main deck, and here an entrance hall, panelled in limed oak and dyed sycamore, gives access to "The Bookworm" and "The Scribe" to port and starboard respectively, and double swing doors open aft to the "Derby Room." This lounge space is divided by a finely wrought metal screen and is veneered in zebrano, horizontally laid out and broken up with white bands, while the main decoration is a mural of horses racing. From the "Derby Room" double swing doors lead to the "Taverna" cocktail bar, which is set out as an old-fashioned country tavern, complete with mock shutters and bamboo screens to give an alcove effect. Decoration on the walls consists of geometric patterns, while on the aft bulkhead is painted a sea and sky scene to create a feeling of spaciousness. The cinema is also available for the tourist passengers, who have their dining room on the main deck. This room, which is air conditioned, extends for the full width of the ship and is 115ft in length and has a seating capacity of 580 at tables for two, four, six, eight, ten, twelve, sixteen, and eighteen. Although of such a large area, the space has been divided by the use of jardinières to give an intimate effect, while the main decoration consists of paintings representing the old world and the new. Linking the main entrance with the dining room is the Olympian gallery, in which exhibitions of modern paintings will be held on each voyage.

The paintings throughout the ship are the work of Mr. William Ware, and the fitting out of the public rooms was carried out by Hampton and Sons, Ltd., Maple and Co., Ltd., A. H. McIntosh and Co., Ltd., Frederick Sage and Co., Ltd., Trollope and Sons (London), Ltd., Waring and Gillow (1932), Ltd., and White Allom, Ltd.; while much of the furniture was supplied by Rowan and Boden, Ltd.

The ship's staff is comfortably housed and the deck officers have single-berth cabins in a house forward on the sun deck, including a suite of rooms for the captain and the staff captain. There is a mess room on the same deck and a smoke room on the sports deck aft of the chart room. The cabins and mess room for the engineers are arranged to port on "A" deck, while the engine-room ratings have two-berth cabins on "B" deck forward and a mess on the main deck. Similar accommodation is arranged for the seamen, their cabins being on "A" deck, while quarters for the catering staffs are on "A" and "B" decks forward and on "A" deck aft with mess and recreation rooms on "B" deck.

On the starboard side of "A" deck there is a general hospital, consisting of three wards, a surgery, dispensary and consulting room, and there is an isolation hospital right aft on the main deck.

Ship and Hotel Services

The first-class and tourist galleys are arranged in a common space on "A" deck with the ovens and other equipment sited between the engine and boiler casings and the auxiliary food preparation rooms arranged to starboard and the bakery to port. Henry Wilson and Co., Ltd., has been mainly responsible for the cooking gear and food preparation machinery, while the Carron Company has supplied the equipment for the crew's galley, which is on the main deck forward. Food is raised from the passengers' galleys to the pantries arranged on the main deck over between the first-class and tourist-class dining rooms by means of three continuously moving electrically driven mechanical conveyors of the suspended tray pattern.

Insulated provision rooms are on "C" deck with the refrigerating machinery immediately below, and other store rooms on the deck over. These spaces are served by two lifts, which, together with the three passenger lifts of eight-person capacity, were supplied by J. and E. Hall, Ltd. On the starboard side of "B" deck amidships is a well-equipped laundry and a separate ironing room; the fittings include washing machines, hydro extractors, dryers and presses, supplied by J. Ritchie, Ltd. Immediately forward on the same deck is a completely equipped printer's shop. Tnroughout the passenger accommodation, crew spaces, public rooms, hospitals, and galleys mechanical ventilation and heating is provided; the whole system, together with the air conditioning plant for the dining rooms and cinema, were supplied by the Winsor Engineering Company, Ltd.

Deck Machinery

General cargo is carried in No. 1 lower and upper 'tween decks, and in No. 2 hold, lower and upper 'tween decks forward, while No. 3 hold aft is arranged for general and refrigerated cargo. For general cargo 142,000 cubic feet is available, while 7400 cubic feet is provided for the refrigerated cargo. Numbers 1, 2 and 3 hatches are served by two 7-ton, two 5-ton and two 3-ton derricks respectively, and for operating the derricks there are six 5-ton Laurence Scott electrical winches. The working and mooring of the ship is effected by an electrical windlass, suitable for taking 2¾in diameter stud link cable, and four 15-ton capstans, two forward and two aft, all supplied, together with the gangway winches, by Stothert and Pitt, Ltd. Steering is by a telemotor-controlled electro-hydraulic four-ram unit having two electrically driven pumps, each of which can move the double-plate fabricated semi-balanced rudder from hard over to hard over in thirty seconds and in eighteen seconds when acting together. The mail and baggage rooms are on "D" deck aft, and they are served by two inclined conveyors, operating, on the escalator principle, from loading spaces arranged to port and starboard on "A" deck. These conveyors and the food conveyors in the galley were supplied by Sovex, Ltd.

Navigation and Safety Equipment

The chart room and wheelhouse are fitted with all the instruments essential for the safe navigation of the ship, such as "Kent" clear-view screens, Sperry gyro compass and bearing repeaters, also Marconi and Decca radar systems and radio equipment to enable communications to be maintained with both sides of the Atlantic.

The ship conforms with the regulations of the 1948 Convention for Safety of Life at Sea, there being adequate subdivision and eleven Stone's horizontal sliding hydraulic watertight doors. Elaborate fire precautions are incorporated in the design, the ship being divided into a large number of zones by "Dreadnought" fire-resisting doors and served by an installation of Grinnell sprinklers associated with a fire alarm system. There is a smoke detecting cabinet and the Pyrene CO_2 equipment is supplied to deal with any fire in the machinery spaces and holds. All the lifeboats are of aluminium alloy and are carried under Welin-MacLachlan gravity davits. The complement of boats consists of fourteen boats, each accommodating ninety-nine persons and propelled by Fleming hand gear, two motor lifeboats, each to carry seventy-five persons, and two emergency boats, capable of carrying forty-six persons.

(*To be continued*)

Electrical Drive of 14in Reversing Cold Strip Mill

In last week's article on the B.I.S.R.A. laboratories at Sheffield we described (page 695) *the reversible cold strip rolling mill which has been installed for the study of variables such as speed, tension and gauge control. Below we give some details of the electrical equipment for this mill.*

THE rolling mill installed in the new B.I.S.R.A. laboratories at Sheffield, as described in last week's issue (page 695), is a high-speed, reversible, four-high, cold strip mill, which will accommodate work rolls from 3½in to 7in diameter, with a face width of 14½in. If required, the mill can be converted into a two-high machine with 14½in diameter rolls. To make the machine suitable for use in research work on various aspects of cold rolling it was designed for operating conditions well beyond those required for normal production.

For example, the speed of the main motor can be varied from standstill to 955 r.p.m., which corresponds to an input strip speed variation of 0 to 1750ft per minute, with 7in diameter rolls. Any speed between these limits can be preset, maintained and repeated, independently of the load. Acceleration can be preset to give any time interval between ten and thirty seconds from standstill to full speed. Strip tension is kept constant at a predetermined value irrespective of strip speed and changes in coil diameter. The tension settings can be varied, back and front: normally the maximum tension available is 2 tons per side, but settings up to 4 tons can be applied. When the mill is stalled the strip tension is automatically reduced, but push button control is provided whereby the running tension can be obtained for short periods. With the top rolls lifted strip can also be reeled from one coiler to the other in either direction, under full tension.

Roll balance and coil ejection are effected by hydraulic means. The coiler drums will take a 4-ton, 56in diameter, 12in wide coil. The wiper and guide table movements are pneumatic. Screwdown is by two 5 h.p. electric motors.

The mill was designed and built by W. H. A. Robertson, Ltd., and the electrical equipment by Metropolitan-Vickers Electrical Company, Ltd.

Electrical Equipment

The electrical equipment consists of three main motors for driving the mill and reels, a motor generator set for supplying the motors with variable-voltage d.c. power, two metadyne sets, a main control board carrying contactors and control gear, a driver's control desk, two control cabinets for local control of the mill, and switchgear for starting the motor generator set, together with screwdown and ventilating equipment.

A view of the mill from the motor end is reproduced opposite. The mill is driven by a 750 h.p., 950 r.p.m., 600V d.c. motor, and each reel is driven by a 200 h.p., 119·5/477·5 r.p.m., 425V, d.c. motor. All the motors are shunt-wound compensated machines, with ring oiled sleeve bearings mounted in pedestals. The undersides of the motor bedplates are machined flat to facilitate movement of the motors on the grill on which they are situated, and so facilitate the process of changing from the four-high to the two-high form, or vice versa, when the gears are introduced or removed. Shaft extensions are

provided at the commutator end of the motors as well as at the drive end, to enable other apparatus to be coupled, if required. Cooling air for the reel motors is supplied by a motor-driven fan, mounted on top of each machine and driven by a 2½ h.p., 1440 r.p.m., squirrel-cage induction motor ; provision is made for mounting a similar fan on the mill motor, if required. Dial temperature indicators with alarm contacts are fitted to guard against overheating of the motors. A tachometer generator for speed indication is chain driven from the mill motor ; in addition a special high-accuracy tacho-generator is provided for electronic slow-speed control.

The main motors are continuously rated, the mill motor having Class A insulation and the reel motors Class B insulation. Overload ratings are 25 per cent for two hours, 50 per cent for five minutes and 100 per cent momentarily. Each reel motor is fitted with a 20in " Perigrip " d.c. brake, capable of producing a torque of 1100 lb-ft and arranged to operate on a combined coupling and brake drum. Overspeed protection is provided, and Selsyn transmitters driven from the reel operate revolution counters in the control desk.

The motor generator set supplying power to the main motors consists of five machines—a slipring induction motor driving three variable-voltage generators and a constant-voltage exciter. Each of the generators supplies one of the main motors, and the exciter supplies d.c. power for machine field control gear, brakes and other equipment. All the generators are compensated shunt-wound machines ; the mill generator is rated at 0/600kW, 0/600V, 990 r.p.m., while the two reel generators are rated at 0/170kW, 0/425V, 990 r.p.m. The constant-voltage exciter has an output of 30kW at 250V, 990 r.p.m., and is level compounded. The driving motor is rated at 1200 h.p., 3300V, 990 r.p.m.

All machines on the m.g. set are self-ventilated and have overload capacities corresponding to those of the main motors. Like the main motors, they are fitted with ring-oiled sleeve bearings carried in pedestals, the two centre bearings at either side of the driving motor being water cooled by means of coolers fitted in the pedestal wells ; protection against water failure is provided by a flow alarm relay. The starting equipment for the m.g. set driving motor consists of a 3·3kV stator switch cubicle and a liquid starter, both of which are hand operated and interlocked.

The larger of the two metadyne sets installed is for use when rolling strip at speeds up to 1750ft per minute, and comprises a 15 h.p., 415V, 1460 r.p.m. squirrel-cage induction motor and four 3·3kW metadynes, two for controlling the fields of the reel motors and two for the fields of the reel generators. The smaller set consists of a 2 h.p., 1425 r.p.m. squirrel-cage induction motor driving a 1·8kW metadyne for exciting the field of the 600kW mill motor generator when the mill is operating at slow speeds under electronic servo control. The motors and metadynes are screen-protected machines.

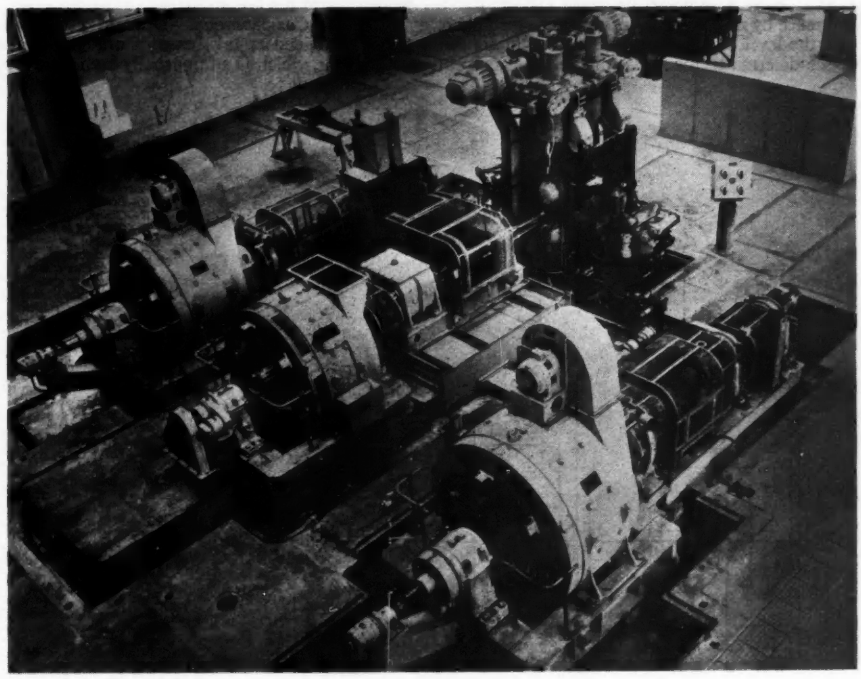
Control gear for both the main and auxiliary drives is mounted on an eighteen-panel open switchboard, 30ft long at the front and having end panels bringing the total length to over 45ft. The panels are slate finished in bright black enamel. Contactors, switches, circuit breakers, instruments and other gear are mounted on the front of the board with the resistances behind facia panels above ; the indicating instruments are in two groups. An electronic amplifier is located in a recess in one of the panels and can be withdrawn for inspection and servicing. Magnetic amplifiers, stabilising units, motor-operated rheostats and other equipment are situated in the space behind the control board.

Two 5 h.p., 960 r.p.m., totally enclosed slip-ring induction motors drive the screwdowns, which are mechanically coupled for dual operation by a 10in magnetic clutch having a maximum torque of 90 lb-ft. A 6in " Perigrip " brake, capable of producing 30 lb-ft torque is fitted to each motor. The clutch and brakes are continuously rated and are supplied via a rectifier at 250V. Selsyn transmitters, driven from the shafts of the screwdown gear, operate receivers coupled to indicators on the control desk.

The back of the control desk can be seen in the top right-hand corner of the photograph reproduced herewith. To allow for more than one operator being at the controls, the control desk is divided into three sections arranged in line. On the central section are the main controls, on the left (of the operator) are the screwdown controls, and on the right the tension controls. The whole desk is 11ft long and is finished in grey stove enamel.

The controls provide for forward and reverse inching of mill and reels, either separately or together and with or without tension applied, and for running the mill up to any preset maximum speed, tension adjustment, screwdown adjustment and other operations. Instruments give indication of main motor currents, strip speed, mill motor revolutions per minute, screw-down setting, number of turns of strip on the reels, strip gauge, torque and load. Provision is made for adding other instruments.

Two control cabinets, arranged for swivelling on pillars near the mill, contain additional screw-down and inching controllers and emergency stop push buttons, which are used for close work at the mill and for threading. One of these cabinets can be seen in our first illustration.



Main Drive Motors and Mill

System of Control

A simplified skeleton diagram of the electrical circuit is reproduced overleaf. The mill and reel motors are each supplied from their own generators, and power for excitation is obtained from a 250V exciter, which is level compounded and fitted with a voltage regulator to keep the voltage constant irrespective of temperature and load variations. This provision ensures that consistent conditions are obtained whilst carrying out experiments, since the whole of the control system is dependent on this exciter.

Fast Speed Control.—The mill motor operates with constant excitation, and its speed is therefore closely proportional to the voltage of the generator supplying it ; this voltage is regulated by a motor-operated rheostat controlling the generator excitation.

The direction of rolling can be selected by means of a switch on the control desk, and the maximum speed can be set by means of a rheostat. A controller having four positions controls the motor-operated rheostat, enabling the mill to be run up to any desired speed. In the " slow " position the mill will accelerate to a slow speed, which is adjustable by a rheostat on the main board, and in the " fast " position it will accelerate to a preselected speed decided by the setting of the rheostat on the desk. At any point below the maximum speed the acceleration can be interrupted by putting the controller to the " hold " position. Speeds up to 1750ft per minute can be obtained using the fast speed control, and the time of acceleration is adjustable over a range of ten to thirty seconds.

Inching and Emergency Stopping.—The mill and reels can be inched individually, or together, with tension applied, operating from the desk. Individual inching facilities are also provided on the cabinets. Slow and fast inching speeds, forward and reverse, are available to the operator.

When the mill is automatically stopped by the safety devices in an emergency the motors are braked regeneratively, tension being held in the strip. Should any of the generator circuit breakers trip, dynamic braking is applied to each of the main motors.

Slow-speed Control.—When it is desired to run the mill at speeds below 200ft per minute without sacrificing good speed regulation, slow-speed control can be selected by a switch on the desk ; the mill motor generator field is now supplied from a metadyne (*MMGM*), which is controlled by an electronic amplifier (*MEA*). This amplifier is a servo device in which the voltage from a tacho-generator (*TG*) driven by the mill motor is balanced against an adjustable reference voltage ; the referance voltage is set by means of a rheostat on the desk and determines the speed at which the mill will run.

This control system is designed to have a high rate of response so that the speed may remain constant after the sudden application of load, for example, during experimental work upon short test lengths of material.

Tension Control.—The tension control system is designed to maintain constant tension irrespective of variations in the strip speed and changes in the diameter of the coils. The kilowatt input to the reel motors is varied in proportion to strip speed, but at any given speed is held constant during the build-up of a coil : this condition is held by varying the motor voltage in proportion to strip speed and keeping constant current in the reel motor armature circuit.

The field of each reel motor is controlled by a metadyne (*LRMM, RRMM*), which operates as a servo regulator to maintain the motor voltage in proportion to the strip speed irrespective of changes in motor speed due to coil build-up ; a speed reference voltage from the reel motor is compared against the reel motor voltage in two

fields on the metadyne. Operating in conjunction with the metadyne is a magnetic amplifier (e.g., *RGMA*), which keeps the reel motor field current within the normal weak and full field values ; a voltage signal derived from a resistance in the motor field is fed into the amplifier, which in turn excites a field on the metadyne.

A follow-up device (*FUD*) embodying a magnetic amplifier and a motor-operated rheostat working in conjunction with a field limit control ensures that if the mill is stopped with a partly wound coil on the reel, the field current will be of the correct value for starting to suit the coil diameter.

To control the field of the generator supplying the reel motor there is a further metadyne (*LRGM*, *RRGM*), which keeps constant current in the reel motor armature circuit. A proportion of this current is compared with an adjustable reference by means of two fields on the metadyne, and the level at which the reference field current is set determines the value of the main current control system, since if the strip broke the metadynes would force the reel generator voltage to a high level in attempting to keep the current constant. Safe conditions are maintained by a voltage limit control (*VL*), which operates through the inertia compensation amplifier to hold the voltage of the reel generator at a predetermined value above the working voltage.

Roll Diameter Compensation.—For a given mill motor speed the strip speed will vary according to the diameter of rolls in use in the mill, and compensation has been provided to cover a range of roll sizes from 3½in to 7in. A calibrated rheostat is mounted on the main control board and acts as a potential divider on the speed signal from the mill motor. Thus a correct measure of strip speed is obtained for application to the metadyne controlling the reel motor voltage, and the strip speed and this voltage are held in correct relationship.

Draught Compensation.—Draught compensation is provided to take care of draughts up to 90 per cent, which is an unusually high figure for obtainable on the tension rheostats by factors of 33, 66 and 100 per cent. With the control switch in the 100 per cent position the reel motor operates up to maximum voltage at half mill speed and is only capable of dealing with a coil of half the normal full build-up of 21in. These conditions are achieved by working the reel motor from mean field to full field instead of from weak field to mean field, as would be the normal practice for half (10½in) build-up, thus doubling the torque for any particular value of armature current. The other taps on the selector switch have a similar effect.

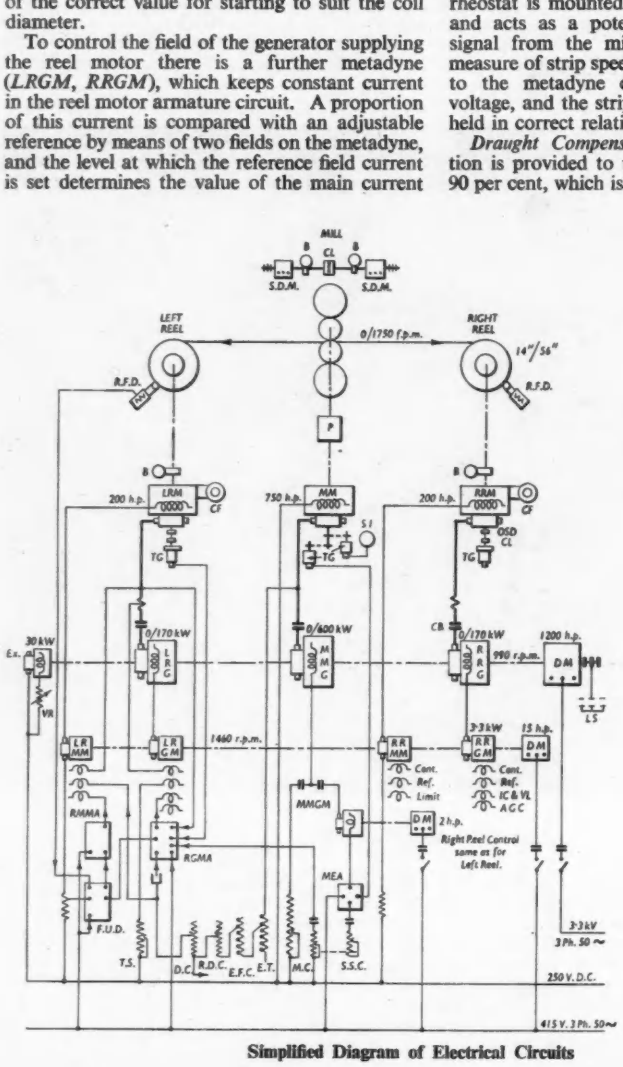
Reeling With Top Rolls Lifted.—Strip can be passed from one reel to the other in either direction when the work rolls are apart at speeds up to 400ft per minute, as required for various purposes, including marking off the strip in test lengths before rolling. With automatic tension control on both reels and no draught on the mill there would be a tendency for the strip speed to increase or decrease, depending on which reel had the higher tension setting, and arrangements were therefore made for the winding reel to operate under speed control and the unwinding reel under tension control.

Each reel is equipped with a radius factor device (*RFD*), which measures the radius of the coil during build-up, and this measurement is used in conjunction with the speed control to adjust the strength of the reel motor field in proportion to the build-up.

Strip speeds up to 200ft per minute are adjusted by altering the reel generator voltage by means of the slow-speed control rheostat on the desk. Good speed regulation is obtained by a servo arrangement, in which the voltage from a tacho-generator coupled to the reel motor is balanced against an adjustable reference voltage, the resultant voltage being fed through the reel generator amplifier and metadyne to control the generator excitation. For speeds above 200ft per minute the reel motor voltage is compared with the mill generator voltage instead of the tacho-generator voltage.

Automatic Gauge Control.—Provision is made for operating the tension control equipment from automatic gauge control apparatus, which is in course of development by B.I.S.R.A.

Screwdown Control.—Fast and slow-speed controls are provided at both desks and cabinets, the maximum designed screw speed being 0·25in per minute.



AGC—Automatic gauge control.
B—Brake.
CB—Circuit breaker.
CF—Cooling fan.
CL—Clutch.
DC—Draughting compensation rheostat.
DM—Driving motor.
EFC—Extrusion factor compensation selector.
ET—Excess tension selector.
Ex—Exciter.
FUD—Follow-up device.
IC and VL—Inertia compensation and voltage limit.
LRG—Left reel generator.
LRGM—Left reel generator metadyne.
LRM—Left reel motor.
LRMM—Left reel motor metadyne.
LS—Liquid starter.
MEA—Mill electronic amplifier.
MM—Mill motor.
MMG—Mill motor generator.
MMGM—Mill motor generator metadyne.
OSD—Overspeed device.
RDC—Roll diameter compensation rheostat.
RFD—Radius factor device.
RGMA—Reel generator magnetic amplifier.
RMMA—Reel motor magnetic amplifier.
RRG—Right reel generator.
RRM—Right reel motor.
RRGM—Right reel generator metadyne.
RRMM—Right reel motor metadyne.
SDM—Screwdown motor.
TS—Tension setting rheostat.
VR—Voltage regulator.

Simplified Diagram of Electrical Circuits

and the tension in the strip. A rheostat for adjusting the tension is mounted on the desk. When standing ready for running (stalled tension), the main current is reduced below the value set for running, to avoid damage to the motors due to local heating, but a push button enables full tension to be applied for short periods during experimental work.

Inertia Compensation.—The necessary change in reel motor torque required during acceleration and deceleration to maintain constant tension is provided by an inertia compensation arrangement (*IC*). The compensation operates through a magnetic amplifier, which alters the level at which the constant-current-control regulates. A rate-of-change-of-speed signal is fed to the amplifier, which supplies a push-pull field on the contant-current-control metadyne and raises or lowers the current level by an amount determined by the position of a rheostat ganged to the follow-up rheostat. Since the position of this rheostat is a measure of coil build-up, the compensation for inertia is automatically adjusted to suit the size of coil.

Speed Limit Control.—Protection against overvoltage, and consequent overspeed, in the event of strip breakage is an important part of the a mill of this kind. A compensating rheostat is mounted on the desk and it changes the level of the speed signal applied to the control system on the entry side so that the signal is a true measure of strip speed.

Extrusion Factor (or Forward Slip) Compensation.—As the mill may sometimes be used for rolling non-ferrous metals, when forward slip may be important, compensation for slips up to 25 per cent has been provided by means of a selector switch on the control desk. This switch has 5, 10, 15, 20, and 25 per cent taps and, when using the control above zero slip, the mill speed is limited according to the tap in use. It compensates for the higher strip speed on the delivery side of the mill so that a true measure of strip speed is fed to the reel motor metadyne.

Excess Tension Control.—Higher tensions than normal can be obtained with this control. Its object is to raise the level of tension that can be obtained in the strip (without increasing the reel motor armature currents) for limited amounts of build-up of strip on the reel and limited maximum strip speed ; it has the advantage of increasing the scope of the mill without necessitating larger motors. A four-point selector switch on the desk provides for increasing the normal range

Technical Reports

Salt Treatment of Snow and Ice on Roads. Road Note No. 18. H.M. Stationery Office. Price 6d., by post 7½d.—This publication supersedes Road Note No. 2, *Chemical Treatments for Icy Roads*. Common salt will melt ice at temperatures down to −6 deg. Fah. and it is the agent most generally used in this country for the treatment of snow and ice on roads. The note outlines the general principles of the treatment and describes the various types of salt available. It gives directions for the use of salt, either alone or with abrasive materials, for treating different kinds and depths of snow and ice. Tables summarise the recommendations for dealing with the various conditions experienced in this country. The recommendations made in the note are based on experiments on British roads, and on Canadian, American and German experience.

The Dielectric Properties of Silicone Liquids (Ref. L/T 247). By E. Rushton (National Physical Laboratory). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 4s., postage 3d.—The liquid silicones previously investigated in report Ref. L/T201 have been studied at still higher frequencies and temperatures. The results at the higher frequencies confirm the findings of the previous report that the relaxation time appears to be practically independent of viscosity or chain length. The power factor of the more viscous liquids of viscosity from 20 centistokes upwards reaches values of 0·02 at a frequency of 9000 Mc/s and between 0·03 and 0·04 at 24,000 Mc/s, and that of the low viscosity (0·65 centistokes) liquid reaches a value of 0·005. The observed variation of permittivity and power factor with frequency can be represented approximately by the simple Debye equations for dipole absorption and dispersion. The permittivity decreases with increasing temperature, the variation of permittivity with temperature being related to the changes in density. The power factor is still relatively small at temperatures up to 150 deg. Cent. at frequencies up to 1 Mc/s.

Smithfield Show and Agricultural Machinery Exhibition

No. I

ON Monday next, December 7th, the Smithfield Show and Agricultural Machinery Exhibition will open at Earls Court, London. It will continue daily, from 10 a.m. to 7 p.m., until Friday, December 11th. This exhibition is the fifth in the post-war series, and, like its predecessors, is organised by a committee representing the Smithfield Club, the Agricultural Engineers' Association, and the Society of Motor Manufacturers and Traders, Ltd.

The " Smithfield " is the only indoor exhibition of its kind to be held annually in London, or, indeed, in this country. This year, it has been stated, the number of cattle, sheep and pigs to be shown is a little below last year's total, but in all 1250 live animals, including representatives of some distinguished herds, are expected. In addition, 55 head of cattle, 146 sheep and 115 pigs have been entered for the carcase section.

Our primary interest, of course, is in the machinery section of the exhibition, and, like its predecessors in the years since the war, farm machinery and implements and equipment for the meat trade will take up the majority of this year's exhibition. Space has been allocated for 370 trade stands, and we have been informed by the organisers that more than thirty firms desirous of showing their products are on a " waiting list " until such time as there may be vacancies in the list of exhibitors. The arrangement of the trade stands is such that visitors are able to see, with rather more ease than is usually possible at the outdoor shows held during the summer, the machines and implements that are now being produced by British engineering firms for almost every arable and dairy farming job. Alongside them there will be shown the agricultural machinery products of a number of foreign firms. As well as heavy and light tractors of all kinds, this year's machinery display will include all kinds of implements for land reclamation and cultivation, and machinery for cleaning and drying seeds and grain. Important items of ancillary equipment such as oil engines and conveyors and loaders will also be on view. There will thus be a great deal to be seen that is of special interest to engineers as well as to farmers and cattle breeders.

About 28,000 invitations to the show have been sent abroad, and, as usual, a large contingent of overseas visitors is expected. This is a matter of special importance in view of the worthwhile contribution that the British agricultural machinery industry is making to the export trade. Last year, nearly 60 per cent of Britain's output of tractors and implements, aggregating more than £62,000,000 in value, was sold overseas.

Information which has been supplied to us by the organising committee of the Smithfield Show and by several of the exhibiting firms enables us to begin below a description of some of the machinery and implements which will be on view at Earls Court next week.

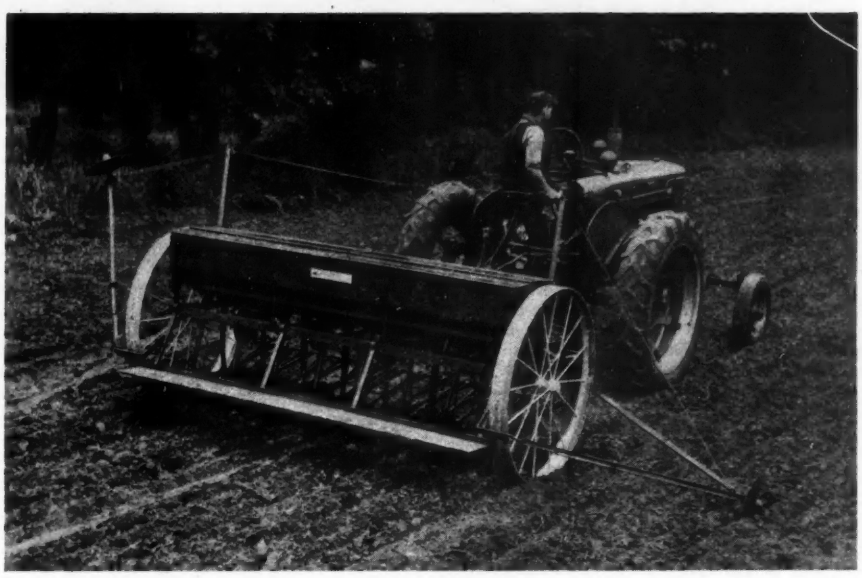


Fig. 3—Grain and Fertiliser Drill—International Harvester

David Brown Tractors, Ltd.

Some months ago, David Brown Tractors, Ltd., Meltham, Yorkshire, introduced an all-purpose light tractor, designated the " 25," which is powered by a four-cylinder vaporising oil engine developing 31·7 b.h.p. at 2000 r.p.m. A description of the tractor appeared in our issue of July 3rd. The firm has now produced a diesel-engined version of this tractor, and will show it for the first time at Earls Court next week. This tractor, which is illustrated in Fig. 1, is known as the " 25D." It is fitted with a David Brown four-cylinder o.h.v. diesel engine, 3½in bore and 5in stroke. The engine, which develops 31 b.h.p. at 1800 r.p.m., is coupled to a three-speed twin-range gearbox, giving six forward speeds between 1·46 m.p.h. and 14·8 m.p.h. and two reverse speeds. Apart from the engine, the new tractor is similar in most of its details to the vaporising engined model, and the makers state that the diesel and v.o. engines are interchangeable in the " 25 " chassis. The " 25D " has been designed primarily for use with mounted implements, but with the retractable drawbar which is fitted it is well suited to trailed implements. When the drawbar is not in use it slides under the rear axle of the tractor.

Among the many implements designed for use with David Brown tractors, which will be shown, is a new adjustable offset disc harrow made by E. H. Bentall and Co., Ltd., Maldon, Essex. It is a mounted implement which has been designed with the export market principally in mind, and can be used with its two gangs of

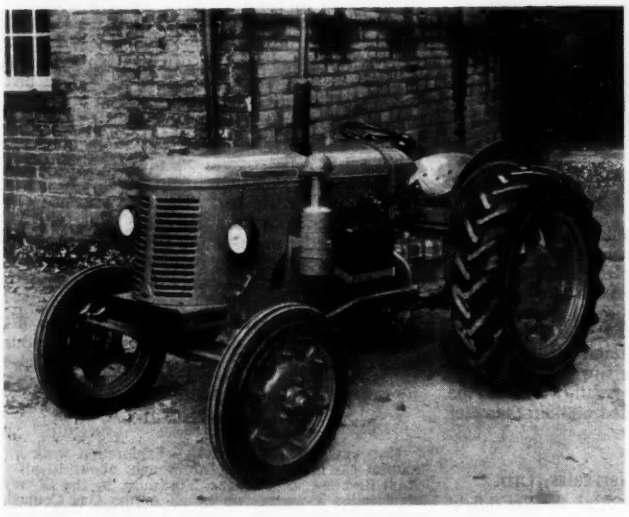


Fig. 1—" 25D " Diesel Tractor—David Brown

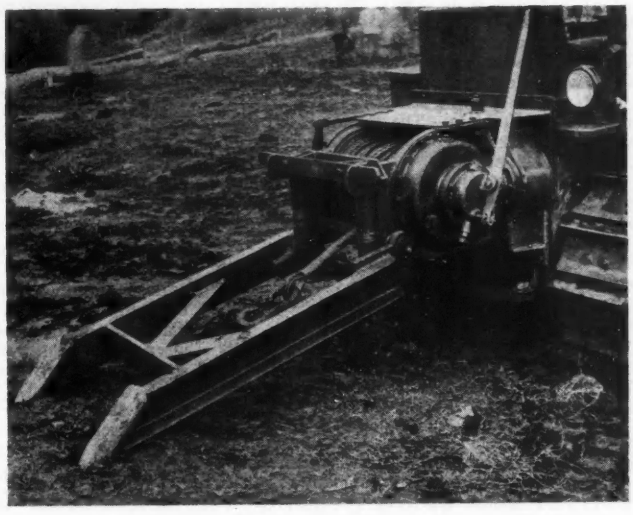


Fig. 2—Boughton Heavy-Duty Winch—David Brown

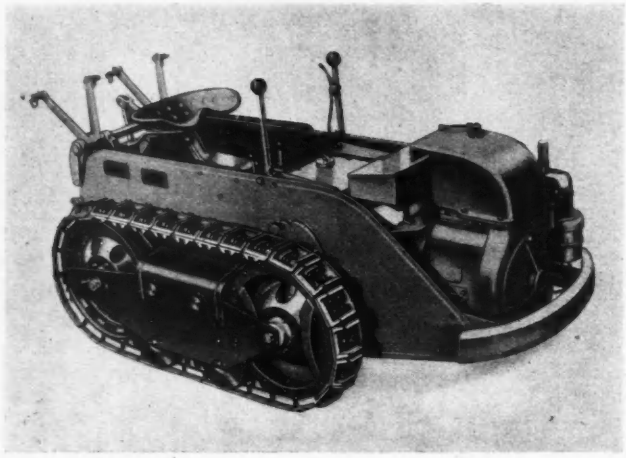


Fig. 4—" MG6 " Tractor—Ransomes, Sims

Fig. 5—Mounted Disc Plough—Ransomes, Sims

discs either trailing or mounted side by side. The harrow is of fabricated steel channel construction, each gang consisting of eight 22in diameter discs. Both gangs are on independent frames, the working widths being 4ft 6in when trailed and 8ft 6in when mounted side by side.

Another item of equipment which is to be exhibited on the David Brown stand is the heavy-duty winch shown in Fig. 2. In recent weeks, the winch has been seen in operation at timber handling demonstrations in Scotland and in Dorset. It is a product of T. T. Boughton and Sons, Ltd., Amersham Common, Bucks, and our illustration shows the winch fitted to a David Brown " Trackmaster " diesel tractor. The winch is of all-steel construction and is fitted with heavy-duty ball and roller bearings. It is totally enclosed and is driven from the power take-off of the tractor, the drive being transmitted to the rope drum by duplex roller chain and spiral bevel gear. Two levers only are needed to operate the winch ; the brake lever situated to the left of the tractor driver and the clutch lever on the right-hand side. The brake fitted to the winch is claimed to be capable of holding any load up to 9000 lb. The drum, of 5¾in barrel diameter, takes 100 yards of ½in diameter cable or 75 yards of ⅝in diameter.

International Harvester Company of Great Britain, Ltd.

At the Royal Show at Blackpool last July, the International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1, exhibited two new tractors which had just gone into production at the Doncaster works. Both will be seen again next week at Earls Court. The first is the " BTD–6 " diesel crawler tractor, which was described in our issue of July 3rd, and the other is the " Farmall Super BMD." This latter tractor is a wheeled machine fitted with a four-cylinder diesel engine, 4in bore and 5½in stroke, giving about 42 drawbar horsepower at 1450 r.p.m. The tractor is provided with power take-off equipment, a hydraulic lift and with a belt pulley.

An addition to the implements and machines produced for operation with " Farmall " tractors is the " Weedall " low-volume sprayer, shown in Fig. 6. The sprayer, which is being made by Pest Control, Ltd., Cambridge, has a tank capacity of 60 gallons, and thus permits operations over a fairly large acreage before refilling is necessary. The interior of the tank is lined with corrosion-resistant material, and the sprayer is mounted on the tractor's three-point linkage and is operated by the power take-off. The effective spraying width is given as 19ft 6in.

Another machine which will be exhibited by the International Harvester Company is the combined grain and fertiliser drill illustrated in Fig. 3. It is a product of the company's Swedish works, although it has been designed to suit British farming conditions. The drill is assembled on a welded steel frame, its rust-resistant hopper having separate compartments for grain and fertiliser. The grain feed is through double-run cups and the fertiliser is fed through star wheels and by the use of cone-gear transmission ten different sowing speeds can be obtained. The drill is built to deal with fifteen rows at a time, the row spacings being 7in, and it is provided with 13in single-disc furrow openers in staggered positions. The planting depth can be accurately controlled by means of a screw crank, and it is possible to make depth adjustments with the furrow openers in either the raised or lowered positions. The main axle of the drill is in two parts, so that there is a double drive and a double lift. In this way, it is claimed, a more even placement of seed and fertiliser can be obtained when sowing other than straight drills ; either seven or eight rows can be sown, if necessary, when finishing off. The overall width of the drill is 10ft 5in. It is mounted on 48in diameter steel wheels.

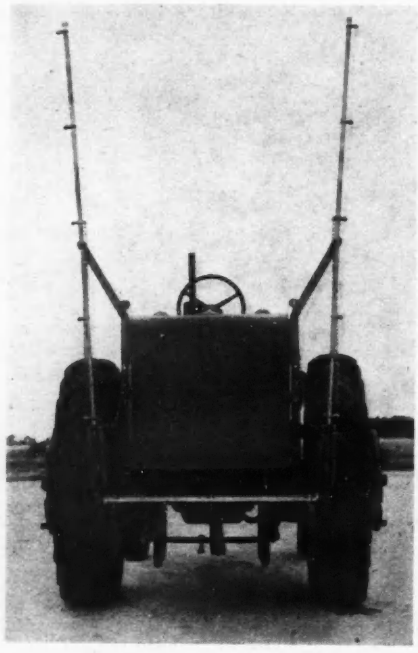


Fig. 6—" Weedall " Sprayer—International Harvester

Ransomes, Sims and Jefferies, Ltd.

One of the oldest exhibitors at the Smithfield Show, or, indeed, at any exhibition of agricultural machinery, is Ransomes, Sims and Jefferies, Ltd., Orwell Works, Ipswich. This year, the firm will show several new products. One is the latest model of the " MG6 " small crawler tractor, a photograph of which is reproduced in Fig. 4. This tractor, the original version of which was introduced in 1936, is designed for work on small holdings and in market gardens. It is therefore an all-purpose machine that is easily manœuvrable in small areas. The dimensions of the new model are : height, 3ft 4½in ; width, 3ft 2in ; length, 6ft 8½in, and with the drawbar removed there is a ground clearance of 13½in. The weight is 13 cwt. The power unit of the " MG6 " is a single-cylinder, four-stroke petrol engine of 600 cubic centimetre capacity, which develops 7 b.h.p. at 2200 r.p.m. The effective drawbar pull is given by the makers as 900 lb in first gear, 800 lb in second gear, and 450 lb in third gear. The equipment of the tractor includes a hydraulic lift and a power take-off shaft designed to run at 700 r.p.m. with an engine speed of 2000 r.p.m. When on stationary work, the power take-off will transmit 7 h.p. There are a number of implements manufactured by the firm for use with this small tractor. Among those that are to be exhibited next week are two mounted single-furrow, all-steel ploughs, one of which has been designed for left-hand ploughing.

The new implements which the firm proposes to show include a four-furrow mounted plough which is a Ford-Ransomes product designed for work with the Fordson " Major " tractor, and capable of turning furrow widths of 10in and 12in. There are also two three-furrow mounted disc ploughs, one of which, the " TD17," is illustrated in Fig. 5. This plough can be directly mounted to medium powered tractors equipped with a hydraulic lift. It will cut 10in deep and can be set for furrow widths of 8in, 9in, 10in or 12in. The frame consists of two beams of twin angle steel bars welded together to form a box section. The discs, which are 26in diameter, are of high-carbon manganese steel, and the ploughing depth is set by a wheel on the landside. Once set, by the operation of a setscrew, the depth remains constant irrespective of the roll and pitch of the tractor. The rear wheel can be adjusted vertically and laterally, and scrapers are provided for cleaning the discs without excessive friction. The other three-furrow disc plough is a reversible one which is claimed to be capable of cutting to a depth of 10in.

Another Ransomes exhibit will be the 4ft combine harvester which was described in our issue of July 10th last.

(To be continued)

Natural Gas Exploration.—Exploration work for natural gas has begun, at Aldbrough, about 10 miles from Beverley, in south-east Yorkshire, by the D'Arcy Exploration Company on behalf of the Gas Council. A seismic survey party equipped with light drilling gear is boring shot holes with a view to establishing the subsurface rock structure and selecting suitable drilling sites.

Main Propulsion Gas Turbine Set for the Oil Tanker "Auris"*

By B. E. G. FORSLING†

To obtain experience with a main propulsion gas turbine under service conditions at sea, the diesel-electric oil tanker "Auris" has been equipped with a gas turbine set which replaces one of the four original diesel engines. A description is given of the set which operates on the simple open cycle with a heat exchanger and independent (low pressure) power turbine. The set has one compressor and two turbines in series, the high-pressure turbine driving the compressor and the low-pressure turbine driving the alternator which supplies power to the propeller motor.

Introduction

THE gas turbine set installed in the oil tanker "Auris" was built to obtain operating experience with a main propulsion gas turbine under service conditions at sea. The "Auris" was originally equipped with four diesel engine-driven alternators and was a suitable ship for the first installation of a main propulsion gas turbine, because until the reliability of the gas turbine under sea-going conditions has been established adequate additional power must be available should it be necessary to shut down the gas turbine at sea. The space made available by the removal of a diesel engine was sufficient for the installation of a gas turbine set of acceptable size, but the narrow width, apart from limiting the air mass flow, led to the adoption of a vertical arrangement.

TABLE I—*Main Design Particulars of Gas Turbine Set*

Design ambient conditions : Barometer ... ... Temperature	14·70 lb per square inch abs. 20 deg. Cent. (68 deg. Fah.)
Design turbine inlet temperature	627 deg. Cent. (1160 deg. Fah.)
Maximum operating temperature	650 deg. Cent. (1200 deg. Fah.)
Compressor high-pressure turbine : Design speed ... ... Maximum speed	5750 r.p.m. 6000 r.p.m.
Low-pressure turbine alternator shaft, design speed	3000 r.p.m.
Design air mass flow (at compressor exit)	25 lb per second
Design pressure ratio of the compressor	4·2

TABLE II—*Performance Data of Gas Turbine Set*

Rated output at design inlet-gas temperature : At the low-pressure turbine coupling At alternator terminals	1200 b.h.p. 860kW
Total fuel consumption at design inlet-gas temperature	840 lb per hour
Fuel rate at design inlet-temperature ...	0·70 lb per b.h.p. hour
Overall thermal efficiency at design inlet-gas temperature	20 per cent

The set was designed for a moderate initial gas temperature to ensure adequate length of life.

In view of the small air mass flow, duplication of compressor cylinders could not be justified, therefore, intercooling during the compression was out of the question. The heat recovery in the heat exchanger was restricted and design conditions limited the thermal efficiency. A low fuel consumption was considered to be of secondary importance, the principal task being to ascertain whether the gas turbine could meet the marine requirements in regard to reliability, rather than thermal efficiency.

Design particulars and performance data of the gas turbine set are given in Tables I and II, respectively.

The fuel consumption is based on a net (lower) heat value of 18,000 B.Th.U. per lb.

Fig. 1 shows a diagrammatical layout of the set. In this diagram the various components of the plant are shown approximately in accordance with actual construction. [The set was described in THE ENGINEER of February 23, 1951.]

Main Design Features

All parts exposed to high temperatures are placed close together so that the differential expansions are kept small and main components can expand freely. For a gas turbine set of this type the ducting constitutes a major problem and a compact layout with short ducts has been achieved at the expense of the accessibility of the low-pressure turbine. This disadvantage was considered acceptable because the low-pressure turbine operates with a low inlet pressure, a moderately high gas temperature and a low blade speed.

The air delivery pipe from the compressor to the heat exchanger is the only duct of any length. Here, a short length is least important because at this point the pressure is highest, the volume flow is a minimum and the temperature comparatively low.

The compressor has twenty-four stages and for this set a compromise had to be made between obtaining high speed, to avoid an unduly large number of stages, and maintaining a reasonable blade length in the last stage. The blading was designed for high stagger to give the highest compressor efficiency.

The high-pressure turbine has seven stages. The rotor consists of a drum with constant diameter. The low-pressure turbine has six stages. Its rotor consists of a hollow drum with constant outer diameter.

In the design the emphasis was laid on high component efficiencies rather than on permitting very high initial gas temperatures. For this reason multi-stage turbines with a high relative blade speed were adopted and cooling was restricted to the shaft ends. The rotor, blading and casing of the high-pressure turbine were

* Paper read before the Institution of Mechanical Engineers on November 27th. Abstract.

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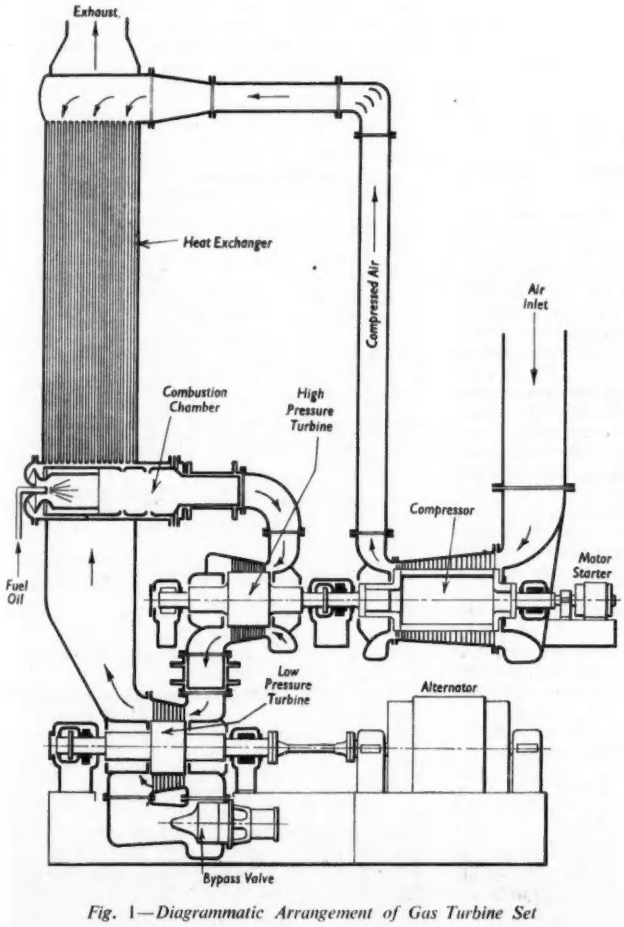

Fig. 1—Diagrammatic Arrangement of Gas Turbine Set

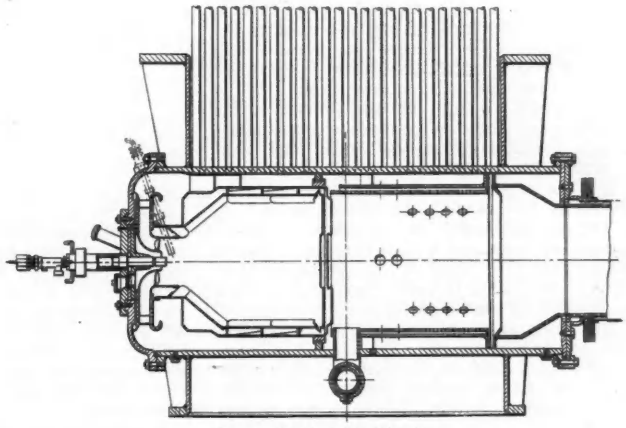

Fig. 2—Combustion Chamber

M Mass flow (pounds per second).
T_1 Intake temperature (deg. K.).
P_1 Intake pressure (pounds per square inch).
R Compression ratio based on static pressure rise from intake to outlet flange.

Mass flow at design inlet conditions $= \frac{M\sqrt{T_1}}{P_1} \cdot 0{\cdot}858$ lb per second

$\eta_{is} = \frac{\left[R^{\frac{\gamma-1}{\gamma}}-1\right]}{\frac{\Delta_t}{T_1}}$ where Δ_t = temperature rise. $\gamma = 1{\cdot}404$.

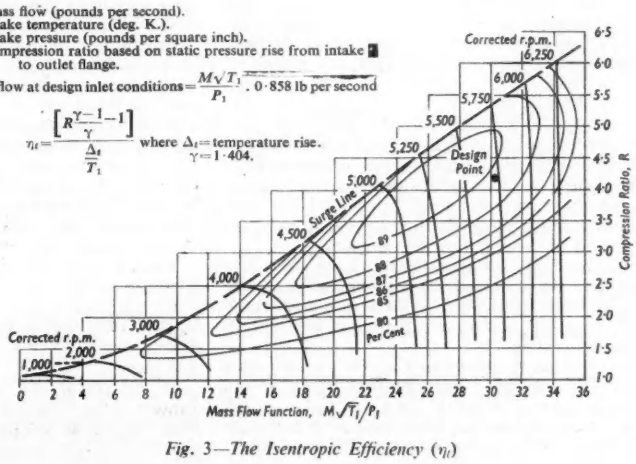

Fig. 3—The Isentropic Efficiency (η_i)

made of austenitic steel, and the stresses have been so selected that an acceptable length of life is expected for a maximum initial gas temperature of 650 deg. Cent. (1202 deg. Fah.).

The air enters the heat exchanger in the upper drum and flows downwards inside the tubes and the exhaust gases flow upwards outside the

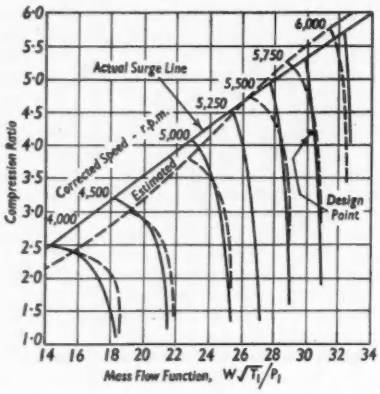

Fig. 4—Comparison Between Actual and Estimated Axial Compressor Characteristics

tubes. From the air inlet the tubes run parallel until, at the air outlet end, the tube stack is divided into two parts, one to each combustion chamber, and forming a " V "-shaped entry for the exhaust gases.

The heat exchanger is mainly a duct of square cross-section ; about 69 per cent is exhaust gas duct, 22 per cent cross-section area comprises inside tubes for the compressed air, and 9 per cent is wall thickness.

This type of heat exchanger is particularly suitable for marine installations for the following reasons :—

(1) The vertical heat exchanger does not take up appreciably more space than a plain exhaust pipe. (2) The volume of the tube stack of the heat exchanger for the same heat transfer and pressure drop is appreciably smaller with longitudinal flow than with cross flow. (3) It is less prone to soot deposits and is easily cleaned. (4) The flow conditions approximate closely to ideal contra-flow with small dead pockets on the gas side only.

(5) The combustion chamber can readily be placed in the heat exchanger outlet drums.

The heat exchanger has 576 tubes of 1·062in outside diameter and a total heating surface of 3500 square feet based on the outside diameter of the tubes. The thermal ratio was estimated at 50 to 55 per cent clean.

The combustion chamber embodies refractory-lined primary zones (Fig. 2) and each has one main burner which can be replaced by another while the set is running, while, for starting, a torch igniter is provided.

The combustion chambers gave a perfectly clean exhaust for the entire operating range on the atmospheric rig, but modifications to the air distribution were required in order to obtain satisfactory combustion at higher loads, when the pressure in the combustion chamber is higher, and therefore the difference between atmospheric and pressurised operation is greater.

Testing of the Compressor

The compressor was tested separately to obtain complete performance characteristics (Fig. 3). The curves of compression ratio against mass flow are very steep, particularly at high speeds, where the mass flow is practically independent of the compression ratio.

Apart from the discrepancy of the surge line at lower compression ratios, the performance of the compressor agreed well with the estimated performance based on Howell's method of calculation (Fig. 4).

As the power input to the compressor could not be measured, the efficiency is based on temperature readings of the air at the inlet and exit and is calculated from the temperature rise of the air, constant specific heat being assumed. This assumption gives somewhat too high values of the efficiency at higher compression ratios.

A check of the performance of the compressor was obtained when the set was tested as a complete unit. The efficiency and the air mass flow then obtained agreed well with the performance curves. The air was inhaled direct from the turbine factory building and a check was made to ascertain any loss in compressor performance. The testing was finished with a repeat test series at the design speed immediately after the blading had been cleaned and agreed well with the earlier test series.

A deposit was found along the leading edges of the blades in the front end of the compressor and was heaviest in the first stage, decreasing rapidly in the following stages. From Stage 9 to the exit end there was practically no deposit.

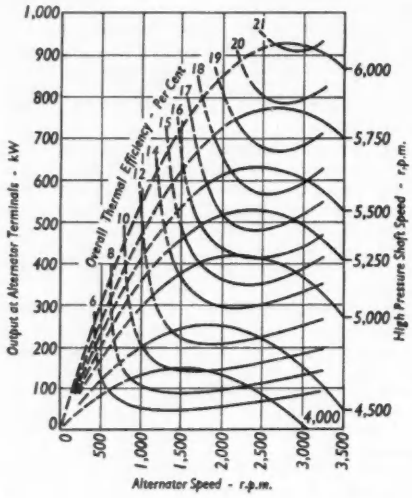
Overall Thermal Efficiency - Per Cent
Output at Alternator Terminals - kW
High Pressure Shaft Speed - r.p.m.
Alternator Speed - r.p.m.

Fig. 5—Performance at Design Ambient Conditions from Tests

The deposit was perfectly even along the leading edges, except in the first two stages, where it had broken off in places. A slight oil leak from the compressor inlet bearing into the machine may have had some influence on the deposits.

Preliminary Shop Testing

Shop testing of the gas turbine set started at the end of June, 1950.

During the first test the set was run for a total of twenty-five hours on gas oil and was taken up to a maximum load of about 700kW (measured at the alternator terminals) which was obtained with an initial gas temperature of 570 deg. Cent. (1058 deg. Fah.), the ambient air temperature being 30 deg. Cent. (86 deg. Fah.), and a high-pressure turbine speed of 5650 r.p.m.

When the set was opened some distortion of the high-pressure turbine casing was found and the tip clearances of the blading had been reduced by about 0·020in at the horizontal joint and increased by about the same amount at the vertical centre line.

During the second test the set was run for sixty-two hours. Alterations in the air supply to the primary zone of the combustion chambers and modifications to the burner tips left the exhaust still smoky, except at light loads. A silencer was fitted to the set, making it less noisy than a steam turbo-alternator.

The smoky exhaust was due to flame chilling by the secondary air and the combustion chambers were dismantled and tested with modified air ports to the secondary zones.

During the third test series the set was run for thirty-seven hours, making a total of 124 hours to date. The load was brought up to 967kW (reduced to design ambient conditions) and the exhaust remained clean up to nearly full speed.

It was found that it was difficult to get the correct inlet temperature to a gas turbine by direct readings owing to uneven temperature distribution and heat radiation. For this reason the turbine inlet temperature (mean value) was calculated from the gas temperature in the crossover duct between the two turbines and the power input to the compressor.

The inlet gas temperature obtained in this way gave 100 per cent combustion chamber efficiency which may indicate that the thermal ratio of the heat exchanger was better, and therefore the heat exchanger air exit temperature somewhat higher than obtained from tests.

The starting procedure is to run the compressor high-pressure turbine unit up to a speed of about 1200 r.p.m. (20 per cent of full load speed) with the by-pass valve open, which requires a power input of about 30kW. At this speed the combustion chambers are lit and the compressor high-pressure turbine unit accelerated by the turbine with diminishing assistance from the starting motor, which is automatically disconnected at about 1800 r.p.m., when the motor torque has dropped to zero. The by-pass valve is closed at a speed of 3000 r.p.m.

During the starting cycle the turbine inlet temperature increased rapidly to a peak of about 500 deg. Cent. (932 deg. Fah.). As the set accelerates the temperature falls gradually to about 350 deg. Cent. (662 deg. Fah.). The set is kept idling at this inlet gas temperature for about an hour in order to approach stationary temperature distribution before the set is loaded up.

Performance Testing

To obtain performance figures at all conditions the set was run continuously for a period of 100 hours and was followed by an endurance test at full load. These tests, which were run on gas oil, brought the total running time up to 327 hours.

Table III gives the performance of the set for the full load test on gas oil and the overload test on heavy fuel oil.

The no-load fuel consumption is about 100 lb per hour and the turbine inlet temperature about 400 deg. Cent. (752 deg. Fah.) when the low-pressure turbine runs at 1500 r.p.m. If the idling speed is increased to 3000 r.p.m., the fuel consumption goes up to about 200 lb per hour, but the turbine inlet temperature drops to 350 deg. Cent. (662 deg. Fah.). These fuel consumption figures, which refer to steady condi-

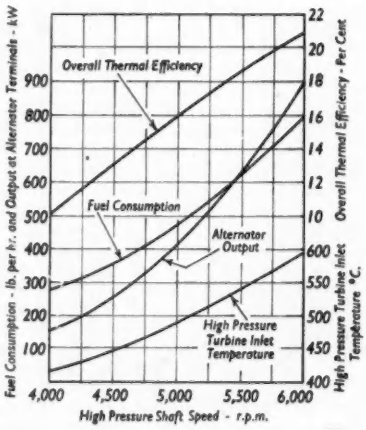
Overall Thermal Efficiency
Fuel Consumption
Alternator Output
High Pressure Turbine Inlet Temperature
Fuel Consumption - lb. per h.; and Output at Alternator Terminals - kW
Overall Thermal Efficiency - Per Cent
High Pressure Turbine Inlet Temperature °C.
High Pressure Shaft Speed - r.p.m.

Fig. 6—Performance Under Service Conditions (Propeller Law)

tions, are about 12 and 24 per cent, respectively, of the full-load consumption.

The thermal efficiency of the heat exchanger works out at 50 to 52 per cent, which is in good agreement with the estimated performance.

Fig. 5 shows the output at the alternator terminals and the overall thermal efficiency plotted against the alternator speed for various speeds of the high-pressure turbine. If the design output is obtained at the design speed and the load at other speeds varied with the cube of the speed, in accordance with the propeller law, the set will, at all speeds, operate very close to the point of maximum efficiency.

The efficiency curves are so flat that this will still apply if there is an appreciable alteration in ship resistance.

Fig. 6 shows the alternator output, fuel consumption, thermal efficiency, and inlet gas temperature plotted against a speed of the high-pressure turbine for the conditions that the speed of the alternator is in accordance with the propeller law and that the design output of 860kW obtains at 3000 r.p.m. alternator speed.

The torque at the coupling of the low-pressure turbine when plotted against the speed of the low-pressure turbine for various speeds of the high-pressure turbine, decreases approximately linearly with the speed at constant high-pressure turbine speeds.

TABLE III—*Results of Tests on the Gas Turbine Set*

Item	Using gas oil		Using heavy oil	
	Test readings	Corrected to design conditions	Test readings	Corrected to design conditions
Compressor inlet :				
Temperature, deg. Cent.	6	20	4	20
Pressure, lb per square inch abs.	14·13	14·64	14·17	14·64
Compressor outlet :				
Temperature, deg. Cent.	160	182	167	192
Pressure, lb per square inch abs.	56·17	58·24	60·03	62·02
Combustion chamber inlet :				
Temperature, deg. Cent.	252	278	260	291
Pressure, lb per square inch abs.	55·61	57·66	59·41	61·38
High-pressure turbine inlet :				
Temperature, deg. Cent. (calculated)	556	598	589	640
Pressure, lb per square inch abs.	54·10	56·09	57·83	59·75
Low-pressure turbine inlet :				
Temperature, deg. Cent.	412	447	438	479
Pressure, lb per square inch abs.	22·58	23·41	23·50	24·28
Isentropic efficiency, per cent :				
Compressor ...	87·0	87·0	86·3	86·3
High-pressure turbine	85·2	85·2	84·3	84·3
Low-pressure turbine	88·4	88·4	89·5	89·5
Heat exchanger :				
Gas inlet temperature, deg. Cent.	344	375	361	398
Gas outlet temperature, deg. Cent.	250	276	258	289
Pressure drop, lb per square inch	0·21	0·23	0·26	0·27
High-pressure turbine speed, r.p.m.	5850	5996	6000	6171
Low-pressure turbine speed, r.p.m.	2800	2870	2940	3020
Compression ratio ...	3·98	3·98	4·24	4·24
Air mass flow, lb per second	27·6	27·9	29·9	30·0
Fuel consumption, lb per hour	773	821·5	925	983
Output (kW) at alternator terminals	875	930	1022	1087
Fuel rate, lb per kW hour	0·884	0·884	0·905	0·905
Overall thermal efficiency, per cent	21·1	21·1	21·4	21·4

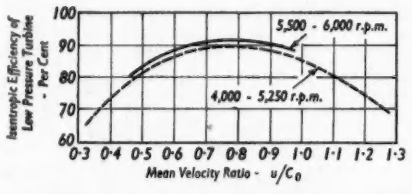

Fig. 7—Isentropic Efficiency of Low-Pressure Turbine

Fig. 7 shows the isentropic efficiency of the low-pressure turbine plotted against the mean velocity ratio. The efficiency is based on the available energy between the static pressure in the crossover duct and the static pressure at the inlet to the heat exchanger (that is, after the right-angle bend behind the low-pressure turbine) allowing for gland leakage and sealing air quantities calculated from the cold gland clearances. The output refers to the turbine shaft, and includes the measured alternator losses and estimated turbine bearing losses. The efficiency exceeds 90 per cent for a large range.

The flow coefficient for both turbines based on the formula :

$$K = \frac{W\sqrt{T_i}}{\sqrt{P_i^2 - P_e^2}}$$

where

K=flow coefficient.
W=gas mass flow, lb per second.
T_i=abs. inlet gas temperature, deg. Cent.
P_i=abs. inlet pressure, lb per square inch.
P_e=abs. exit pressure, lb per square inch.

At the design speed the flow coefficient of the high-pressure turbine is 13·5 per cent and that of the low-pressure turbine 8·5 per cent larger than anticipated. Both turbines are thus too large, and the set operates at a lower compression ratio and with a lower compressor efficiency, the loss being over 1 per cent.

The efficiency of the high-pressure turbine is slightly lower than anticipated (about 0·5 per cent), but the pressure drop between the compressor outlet and the high-pressure turbine inlet is less than estimated (3·7 per cent instead of 4·2 per cent) and the efficiency of the compressor much better than expected (3 per cent). The overall efficiency of the compressor and the high-pressure turbine is therefore better than allowed for.

As a result, for any one fuel setting, the compressor and high-pressure turbine line runs at a higher speed and the set operates with a lower inlet gas temperature than anticipated. For instance, in order to bring the set up to design inlet gas temperature of 627 deg. Cent. (1160 deg. Fah.), at the design ambient temperature of 20 deg. Cent. (68 deg. Fah.) the speed of the compressor and high-pressure turbine would have to be 6200 r.p.m. The set would then operate at its design compression ratio giving a net output of 1100kW, with an overall thermal efficiency of 22 per cent. As the efficiency of the compressor starts to fall off above the design speed of 5750 r.p.m. (Fig. 3) this speed increase is, at higher loads, associated with further loss in compressor efficiency.

TEST ON HEAVY (RESIDUAL) FUEL OIL

The testing on heavy fuel oil comprised sixty-six hours of preliminary running, including alternator testing, a continuous run of 270 hours, of which the last 240 hours were at full load (6000 r.p.m.) and a further twenty-seven hours in two shorter runs, making a total running time of 363 hours.

The oil had a nominal viscosity of 1500 seconds Redwood No. 1. Table IV gives the main particulars of the fuel from samples taken at the beginning, middle and end of the testing period.

The oil was burnt as received and preheated to 100 deg. to 105 deg. Cent. (212 deg. to 221 deg. Fah.).

TABLE IV—*Particulars of Sample Fuels*

Specific gravity at 60 deg. Fah. ...	0·98	0·957	0·956
Viscosity, Redwood No. 1 at 100 deg. Fah., second	989	1440	1510
Water, per cent	0·05	—	—
Carbon residue (Conradson), weight per cent	8·6	9·9	9·7
Sulphur, weight per cent	2·5	2·15	1·98
Calorific value (gross), B.Th.U. per lb	18,690	—	—
Ash content at 525 deg. Cent. (977 deg. Fah.), weight per cent	0·062	0·069	0·085
Vanadium as V_2O_5, weight per cent	72·0	70·0	54·4

When burning heavy oil the combustion chambers operated at a hotter temperature and the flames were larger than when burning gas oil, which led to a smoky exhaust at high loads. The loss due to incomplete combustion was about 2 per cent.

During the endurance test the high-pressure turbine suffered from ash deposition.

The pressure drop across the heat exchanger on the gas side increased gradually. After about 200 hours the heat exchanger cleaned itself and the pressure drop fell almost to the original figure, but increased again during the remaining time of the test.

The flow coefficients of the turbines plotted against time show the rate of deposition and, as expected, the flow coefficient of the low-pressure turbine remained constant, due to the absence of any deposit on the blading.

The flow coefficient of the high-pressure turbine fell from 16·2 to about 15·0 at the end of the run, but the rate of deposition appears to have slowed up towards the end of the run.

Table V gives the performance from test readings taken at three-hour intervals, together with the result of readings taken at the end of the final run.

TABLE V—*Continuous Full Test on Heavy Fuel Oil*

	Gas oil	Continuous full-load test on heavy fuel oil					Final test after intermediate shut down
Total hours on heavy fuel	—	69–78	120–129	201–210	261–270	273–276	—
Hours at full load	—	3–12	59–63	135–144	195–204	207–210	—
Speed of high-pressure turbine, r.p.m.	6000	6000	6000	6000	6000	6000	6000
Speed of low-pressure turbine, r.p.m.	3000	3000	3000	3000	3000	3000	3000
Output at alternator terminals, kW	930	925	946	980	988	1002	941
Turbine inlet temperature :							
Deg. Cent.	599	606	622	640	646	648	623
Deg. Fah.	1110	1123	1152	1184	1195	1198	1153
Overall thermal efficiency	21·10	19·90	19·70	19·58	19·52	20·15	20·30
Compression ratio	3·98	3·97	4·12	4·26	4·36	4·33	4·06
Pressure ratio of high-pressure turbine	2·38	2·40	2·48	2·55	2·61	2·58	2·45
Pressure ratio of low-pressure turbine	1·56	1·56	1·57	1·58	1·58	1·59	1·57
Pressure drop across heat exchanger on the gas side, per cent	1·49	1·65	1·67	1·76	1·77	1·60	1·68
Combustion chamber efficiency	1·00	0·975	0·977	0·972	0·965	0·960	0·980

The turbine inlet temperature (to the high-pressure turbine) is calculated from the crossover temperature between the two turbines and the energy absorbed by the compressor from temperature readings. The efficiency of the combustion chamber is based on this temperature and the average air exit temperature from the heat exchanger. The thermal efficiency refers to the lower heat value of the fuel.

Each column for the continuous run is based on the average of four consecutive readings at three-hour intervals, except the last column of the test, which is based on tests at one-hour intervals.

NATIONAL POWER FARMING CONFERENCE.—The fourth National Power Farming Conference is being arranged to take place at Cheltenham on February 9, 10 and 11, 1954. The general theme is to be the use of labour and machines for the most economic production in farming. At the conference a variety of subjects will be discussed, such as land drainage ; the design of combined root and grain harvesters and of hill farming machinery ; grain handling and storage, and agricultural electrification. Full details of the conference can be obtained from the Organiser, National Power Farming Conference, Dorset House, Stamford Street, London, S.E.1.

Iron and Steel Institute

AUTUMN GENERAL MEETING

No. I

THE autumn general meeting of the Iron and Steel Institute was held on Tuesday and Wednesday, November 24th. and 25th., at the offices of the Institute, 4, Grosvenor Gardens, London, S.W.1. The President, Mr. James Mitchell, C.B.E., occupied the chair, except during the afternoon of the first day, when his place was taken by Mr. Richard Mather, past-president.

In his opening remarks Mr. Mather, on behalf of the council, wished to take this first public opportunity to express thanks to all the Institute's friends in the Netherlands who did so much to make that visit so successful. He went on to say that the Council had recently had an opportunity of purchasing a sixty-year lease of the present offices of the Institute and he wished to thank the many companies who had helped in the financial problems involved. About future meetings, Mr. Mather reminded members that an invitation had been accepted from Jernkontoret to hold a meeting in Sweden from June 4 to 18, 1954. The recommendation that the Hon. R. G. Lyttelton, vice-president, be elected president at the annual general meeting in 1954 was then approved.

There followed a joint discussion on three papers :—

THE EFFECT OF EMISSIVITY AND FLAME LENGTH ON HEAT TRANSFER IN THE OPEN-HEARTH FURNACE.

By M. W. THRING.

SYNOPSIS

Recent developments in port design and the aerodynamics of flames are taken into account in calculating the optimum flame for the open-hearth furnace. This is done by postulating a simplified furnace and flame, and calculating in detail the temperatures along the flame and the roof. Certain simplifying assumptions are necessarily made in the calculations. Four types of flame are considered, each for three different fuel-input rates, and the comparison indicates the optimum flames for three distinct phases of the open-hearth process—charging, melting and refining.

EXPERIMENTS ON FLAME RADIATION IN AN EMPTY OPEN-HEARTH FURNACE.

By W. P. CASHMORE and M. W. THRING.

SYNOPSIS

To find the effect of changing the flame conditions on the radiation along the flame in an open-hearth furnace, a series of eight flames was studied in an empty 100-ton furnace maintained in as steady a state as possible. It was found that steam quality had a large effect, the overall radiation being 7 per cent higher when slightly superheated steam was used for atomisation than when 0·85 dry steam was used. Colder oil with higher steam quantity and hotter oil with lower steam quantity gave 6 per cent more radiation than the reverse conditions, implying that the optimum steam/oil ratio rises when the oil viscosity increases. A comparison with the Ijmuiden results on oil flames with cold air shows that air preheat of 1000 deg. Cent. doubles the peak radiation owing to an effective increase in flame temperature at this point from 1200 deg. Cent. (cold air) to 1600 deg. Cent. (preheated air).

THE LENGTH OF OIL AND GAS FLAMES.

By A. L. CUDE.

SYNOPSIS

There is a need for a simple relationship between flame length and the quantities and velocities of air and fuel passing through the burner. Such relationships determining flame length are deduced from the theory of turbulent jets in forms suitable for application to oil and gas burners. The terms of the equations depend on measurements of flow, pressure, and density, together with an empirical coefficient.

An account is given of experimental work designed to verify this relationship for town gas and gas oil burning in open vertical flames. Good agreement between theory and practice was found for straight jets, and it was possible to extend the same form of equation to swirling jets.

The experimental values of the equation coefficient may not be directly applicable to works practice because of the difference in conditions, but suitable values are easily obtainable by experiment when required. For some purposes it is not essential to know the exact value of the coefficient. The relationship cannot be applied to very long lazy flames, nor to turbulent flames in very narrow combustion chambers.

Some data on the interference between two flames and impingement on a flat surface are given, showing the order of magnitude of these effects.

The afternoon meeting was concluded with a discussion of a paper, "Water Cooling of Open-Hearth Furnaces," by A. M. Frankau.

DISCUSSION

Mr. R. W. Evans (Steel Company of Wales) : These papers serve to remind us of the intense attention that is now being paid to the question of the transfer of heat from flames to liquid and to solid phases, not only in this country, but in Europe and in the United States, although it is true to say that the greatest attack on the problem is coming from this country.

Professor Thring's paper is one in which he has achieved what I would consider an almost impossible task. He has actually calculated mathematically not only the time that it is going to take us to melt a charge, but he has thrown in for good measure the roof temperatures that would prevail during the process.

Professor Thring has said that he does not tell us absolutely what happens in the furnace, he does not give us the absolute answers ; but he is trying to tell us comparatively what happens, and there is no doubt that as the state of our knowledge progresses and as we get to know more about slag, conductivity and various other thermo-chemical reactions and factors in the open-hearth bath, we shall be able to take this method of calculation further still.

In the paper by Professor Thring and Mr. Cashmore we see the second step taken, and that is that they endeavour to show, by altering levels of steam quality, oil temperature and steam/oil ratios how best one may endeavour to achieve the radiating flame which Professor Thring postulates in his first paper. In the third paper, that of Mr. Cude, a relationship has been sought between the quantities and velocities of air and fuel delivered to the furnace and the flame length, and in order to establish those relationships the empirical coefficients for given burners have been introduced and verified.

In all these matters one must bear in mind that the ultimate aim is to produce economically more tons per hour.

In the first place, Professor Thring admits that there is no known method at present of preserving the luminous emissivity of a flame right along the bath if you have quick combustion. Really these two things are paradoxical. You cannot have a very fast-burning flame which is at the same time highly luminous. It is just not possible, because the luminosity is given by the small particles of carbon, and if you burn fast you burn them up quickly and the flame loses its luminosity. The only way in which you might preserve the emissivity of the flame right along is as Professor Thring suggested, namely, you might inject along the furnace small wisps of carbon particle of one sort or another. Generally speaking, I believe that high-temperature flames are not highly emissive, and when we are melting scrap we may require a flame with high emissivity or we may not ; but one thing of which I am certain is that we want a high-temperature flame. I have seen flames in open-hearth furnaces on coke oven gas with no illuminant at all. I remember one furnace in which you could see nothing, but it was one of the fastest melters that I have ever seen. The strange thing about it was that even when the charge was under cover of the slag, provided the carbon was not high, that flame was quite invisible, but it could melt the charge down and melt it up very quickly, even when it was flat ; but once the carbon was up above 0·40 per cent the furnace had had it, because then you got the slag in froth and there was no way of getting it down unless there was luminosity. That flame was not radiating in the ordinary sense at all ; or rather, it was radiating on the invisible bands but not on the visible bands ; but it was evidently bringing the very best quality to the furnace with regard to transfer of heat by convection.

We have to be careful when we talk about the actual power of the flame in radiating and the emissivity, because there is no doubt that you can melt tremendously fast without any luminous emissivity at all.

There are one or two other things that one has to be careful about in defining flames in this way. I believe that the flame character probably has a vital effect on the chemistry of the charge. Some flames will oxidise the charge much faster than others. We know that when we are putting very high volumes of oil into an open-hearth furnace it is quite possible to oxidise the charge very much faster than would be possible in a producer gas-fired furnace. This is probably due to the very great entrainment power of the oil jet. If we take the amount of pig iron that we have to carry in a furnace to melt the charge completely, we can see the difference between the percentage necessary with the producer gas-fired furnace and the percentage necessary with the fast-driven oil-fired furnace. There has to be much more pig iron with the oil-fired furnace.

Dr. J. H. Chesters (United Steel Companies) : Some seven years ago there was a discussion in this room on the Factors of Furnace Design, and the opinion was expressed then that it was quite impossible to design a furnace in the sense that one designs, for instance, a bridge, the reason being that one had not got the background data and the fundamental equations necessary.

During the last seven years an enormous amount of work has been done and we shall soon have equations that will enable anybody who is clever enough (and it is still necessary to be quite clever to do it) to work out in advance what a furnace would look like and in particular what would happen if certain changes were made.

We are now beginning to know quite a lot about the flow pattern. I believe that in that field our great chance is twofold : on the one hand, I think we have to simplify existing furnaces wherever we see possibilities of so doing without losing efficiency. For example, on oil-fired furnaces we are moving away from the sort of appendages which really derived from the gas-fired furnaces. On the other hand, we have to start with extremely simple flow patterns which everyone says are obvious when they have seen them, and work up to quite complex things, culminating in different shapes, such as three rectangular blocks at right angles,

which are an approximation to open-hearth furnaces.

On the radiation pattern the one factor that has not been tackled is preheat. The work at Ijmuiden has so far been with very low preheats ; it is intended in the near future to start work with higher preheats, but still not with those anywhere near the neighbourhood of the kind of preheat that we get in the open-hearth furnace.

I should like to ask one or two questions in connection with the work done at Guest Keen Baldwins Iron and Steel Company.

I should like to ask just how much reliance we should place on the question of superheat. It is nothing less than extraordinary to me that, in going from 85 per cent dry steam to only 8 deg. Fah. of superheat, one should get a 10 per cent increase in radiation. I looked up some of the tables given in Special Report No. 37 to see what that would mean in terms of our estimates of reduced melting and refining time, and I find that it is of the order of thirty minutes. If it is a fact that merely by getting from some moderately poor steam to some still moderately poor steam we can get an improvement of the order of thirty minutes, then we ought not only to know about it but we ought to be doing it without further work. I should like to appeal to anyone else who has information on the effect of superheat to give it.

On the other hand, from certain discussions to which I have not been a party, I understand that the swing recently has been quite big in opinion among people much as ourselves who are always talking about these things, and that whereas ten years ago we said quite confidently that, according to calculations, 90 per cent of all heat transfer in the open-hearth furnace was by radiation, the swing has gone to the other extreme almost and we have people like Mr. Evans saying that it is not 90 per cent to 10 per cent but 10 per cent to 90 per cent. I suggest that it is equally dangerous to assume that there is an enormous amount in this radiation business as it is to "pooh-pooh" the work done at Ijmuiden and say that it is not radiation that matters.

Mr. A. Aitken (Colvilles, Ltd) : There are some primary questions that I should like to ask the authors.

(1) What type of burner was used in the trials ?

(2) Does steam pressure mean line pressure or pressure at the burner tip ?

(3) What effect on the observations would theoretical furnace pressure (zero at sill) have made ? I would suggest that some differences as evidenced in the curves would have been ironed out.

(4) With only 8 deg. Fah. superheat was there no possibility of the steam being wet by the time it had mixed with the oil ?

(5) The suggestion by the authors that the optimum steam/oil ratio is greater with cold oil is no doubt true, but how much of the higher peak radiation with cold oil may be coming from the greater weight per unit volume if the method of metering were the same for both temperatures ? This may mean a difference of 5 per cent in the heat energy used between hot oil and cold oil for the same metered figures.

However, we have all been reassured from these results that for the ultimate radiative power of a flame we should use (*a*) hot oil rather than cold oil, (*b*) superheated steam rather than wet steam, and (*c*) optimum steam/oil ratio.

But this is far from the whole story in applying this in actual practice. I would say that the results of this paper are more readily applicable to hot metal practice than to cold metal practice simply because a flame of high radiative power is necessary for a much longer period with hot metal.

I do feel, as does Dr. Chesters, that the time is ripe for the industry to engage cooperatively in pilot-scale plants where expensive fundamental projects, such as this, may be carried out for the benefit of the industry as a whole instead of one single firm bearing the brunt of the cost.

Dr. A. H. Leckie (B.I.S.R.A.) : What interests us in Professor Thring's calculations is the extent to which the calculations are valid in practice. Professor Thring himself has given a hint of this note of caution in saying that he has considered radiation only. He divides it into three periods : the charge period, when the charge is at a relatively low temperature ; the melting period, which he says rightly is the critical one ; and the refining period, where the heat flow in the furnace is of less importance. I think that the answer to the point made by Dr. Chesters as to whether we are going haywire on convection now instead of on radiation is that it is simply a matter of these three periods.

During the charging period, when the charge is cold, I think it is true that convection is probably the more important thing. During the melting period undoubtedly radiation plays an important part, and Professor Thring's calculations are probably the most applicable. I do not know what Professor Thring's views are about the refining period ; I could not quite gather that from his paper ; but it seems to me that, although the temperature level is very high and therefore radiation should be important, the temperature differences are also small, and therefore flame velocity may play some part in securing maximum maintenance of temperature for the minimum fuel consumption.

So if we consider the actual melting down period as the one for which Professor Thring's remarks are really valid, that is only about one-third of the charge. I therefore feel that these calculations have to be regarded in that light—that they are applicable to one-third or something like that of the charge only, and we need to be a little bit careful before we say that the design of the furnace can be based on those calculations. The calculations are, however, a very important beginning to the difficult matter of designing a furnace on a really sound basis.

Professor Thring has also emphasised again —and I think this has to be strongly emphasised—that a higher thermal efficiency does not necessarily go with a very high output. In that way the open-hearth furnace differs from some other heat exchange plants.

With regard to the paper by Mr. Cashmore and Professor Thring, the main criticism that can be made is that there was no heat sink in the furnace during the time of the trials. I suggest that if the work is ever repeated there should be some water tanks with large calorimeters that could be gunged in through the doors at the beginning of the trial and so provide a heat sink which would give some measurement of heat transfer.

Mr. R. H. Baulk (Samuel Fox and Co., Ltd.) : Over the last six weeks we have been conducting an observed trial on a furnace using normal wet steam one week and superheated steam the following week. The amount of superheat used varied throughout the test period, but averaged 10 deg. Fah. This is a little greater than that used in the authors' work. However, the results have shown no improved performance at all.

The authors state that the radiation from a flame is reduced by the use of steam. On the other hand, increased steam flow is known to produce a fiercer flame and faster melting. These two effects would appear to work in opposition.

Surely there must be some compromise point at which the total heat transfer due to both radiation and convection is a maximum. It would be interesting to see some curves showing how the convection as well as the radiation varies with steam/oil ratio. This stresses the urgency of having an instrument which can measure convection so that we can study it as thoroughly as the radiation has been studied.

Mr. A. B. Pritchard (Shell-Mex, Ltd.) : The author states in the introduction of the paper that "oil must be evaporated before it will burn," and "provided that the spray is fine enough, evaporation proceeds at a greater rate than combustion." I would suggest that these statements are rather too sweeping and are probably influenced by the fact that the experimental work was carried out on gas oil, which is very readily vaporised, or in furnaces where the ambient temperature was high enough to substantiate the proviso.

The formula is based on the assumption that the speed of combustion is controlled by the rate at which the air required for combustion is entrained into the fuel spray ; but I think it is known that a droplet of fuel oil takes a definite time to burn, depending on its size and surrounding temperature as well as the availability of the necessary oxygen.

From my experience I would suggest that in many cases the quality of atomisation of the oil will have an overriding effect on flame length, especially when heavy fuel oils are used where the ambient temperature is relatively low, such as in boiler firing.

In these cases the value of the constant will vary for each individual application, depending on such things as the oil temperature in the burner, the efficiency of the air/oil mixing arrangements, the amount of refractory support and even the position and extent of uncontrolled air infiltration, these factors being apart from the mechanical condition of the burner.

It is in such cases as these that certain of the conclusions given in the paper probably do not apply ; I refer to the statements, first, that increasing the flame temperature increases the flame length, and secondly, that increasing combustion air temperature lengthens the flame. I can assure Mr. Cude from my own experience that both of these treatments are in some cases very effective means of accelerating combustion and shortening a flame.

There is another of Mr. Cude's conclusions which is not borne out by my experience, and that is the conclusion that for otherwise comparable conditions the effects of burner design were not large. Mr. Cude was probably fortunate in that his experiments were carried out with two oil burners which are recognised to be good atomisers. In many cases burners of unsuitable design will have a very marked effect on combustion conditions, including flame length.

In the case of high-temperature furnaces, the basic assumption on which the formula is based is probably as true for oil as for gas for all practical purposes, although even here Mr. Cashmore and Professor Thring infer that the quality of atomisation plays some part in the rate of combustion.

(*To be continued*)

MARINE CONSTRUCTION.—T.I. Aluminium, Ltd., has published a brochure with the title "Marine Construction," which deals with the products of the company as applied to shipbuilding and illustrates pictorially the production of plates and extrusions and also the various ship components built in light alloy.

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GOVERNMENTAL SUPPORT FOR RESEARCH

The Government decided two years ago to reduce the financial aid made available to the Department of Scientific and Industrial Research and through that Department to the various industrial research associations, numbering some forty, that depend upon it for some part of their financial support. Ever since it has been subjected to severe criticism, not only from industry but from the Advisory Council for Scientific and Industrial Research itself, a point made clear in the reports of that body for 1950–51 and 1951–52. The earlier report referred to repeated delays affecting the post-war building plans of the D.S.I.R., to the lagging behind of expenditure on buildings below the expected rate of £1,000,000 annually, to checks in the growth of staff, and to the fact that "effective planning of research must be based on reasonably firm budgeting expectations for several years ahead;" and in the 1951–52 report the Council expressed "considerable anxiety at the delay in giving effect to D.S.I.R.'s plans" and it reviewed "the relation between our scientific needs and our scientific resources with steadily deepening concern."

The Government has now relented. As Sir Ian Heilbron, chairman of the Council, announced last Friday, the cuts are to be restored in full. A defined programme has been drawn up for expanding the work of the Department, and through it the amount of research carried out by industrial associations. Moreover, the Treasury has yielded in another very important way. It appears that a total sum to be expended over the next five years has been agreed upon and that any surplus left over from the planned expenditure in any one financial year will not, as heretofore, have to be returned to the Treasury, but will be carried forward into the next. That does not amount quite to "the absolute revolution in the affairs of State" by which Sir Ian referred to it. For the arrangement is closely comparable with that by which the Government makes finance available through the University Grants Committee to assist universities financially. But it is nevertheless very welcome and is in line with recommendations made for years by industry and the Advisory Council itself. Apart, however, from that concession, the announcement made by Sir Ian proves less exciting upon a more careful scrutiny than it appeared at a first hearing. Government announcements often do sound more impressive than they really are! Over the next five years £6,000,000 is to be spent on research buildings, including the construction of a new ship tank at the National Physical Laboratory and a new Road Research Laboratory, the completion of the Mechanical Engineering Research Laboratory at East Kilbride, the completion of Water Pollution Research Laboratories at Stevenage, and Radio Research Laboratories at Datchet, and various other works. But as long ago as 1945 it was expected that expenditure upon works of this character would reach £1,000,000 per year. Ever since expenditure has lagged behind estimates, and it has lagged really seriously behind during the last two years. A rate of expenditure increased by a mere £200,000 per year will not contribute much to making up for lost time! Again, an agreement has been reached with the Treasury whereby Research Associations will benefit over the next five years by £800,000 over and above the grants already being received. The total expenditure of industrial research associations during the financial year 1952–53 is likely to reach about £4,000,000, of which the Department will have contributed about £1,333,000. There will be no increase in the Department's contribution in 1953–54. But thereafter it is planned to increase it by annual increments to about £1,680,000 in 1958–59. But if, as has always been and will continue to be the purpose of the Department, new industries are to be encouraged to set up research associations and already established research associations are to be encouraged to expand their operations, increased support would have been inevitable anyway. The virtue of the arrangement lies less in the promise of enhanced support than in the certainty with which the Department can now plan ahead untroubled by fears that the amount of money available may be varied unpredictably as between one year and another.

It is, of course, as well not to look a gift horse in the mouth. The intention to spend £6,000,000 upon research buildings during the next five years is very welcome. Particularly at East Kilbride urgently needed research has been sadly delayed by the lack of suitable buildings; and if British shipbuilders are to remain in the forefront of shipbuilding design the need is very urgent for a testing tank comparable with, or preferably better than, any existing abroad. But this relatively large expenditure is of a capital nature. The actual expenditure upon research will not be greatly increased. The figure for research associations has already been given. That for research establishments within the D.S.I.R. will increase from under £4,000,000 per year as at present to about £4,500,000 per year by 1959. But always until now research bodies, whether directly under the Government or receiving support through the Department, have needed to hesitate before embarking upon researches expected to yield valuable results, but requiring more than one year of continuous work, for fear that financial stringency might be imposed by Government decree. The decision to make a quinquennial grant instead of annual ones will make it possible for the Department and all the industrial research associations that depend upon it to plan their work ahead more confidently; and to acquire and expand staffs at a rate adequate to the increasing amount of work undertaken. In fact, to quote our own words in a leading article in our issue of May 2, 1952, the Government has come to a realisation that "come boom, come slump, come changes in the complexion of Governments, come the need to re-arm, steady financial support of the work of the D.S.I.R. must well repay this country."

MINES AND QUARRIES

The object of the new Mines and Quarries Bill, published last week, is to consolidate and revise statutory decisions concerning safety and health in all mines and quarries. It is broader in scope than the Coal Mines Act, 1911 (which itself applies also to mines of stratified ironstone, shale and fireclay), and it comprises the relevant parts of the several Acts which at present apply to quarries. Coal mining is, of course, the principal industry concerned; out of a total of 1716 mines at work under the 1911 Act in 1950 about 1490 were coal mines. In making such a revision the aim must be to spread best current practice as widely as possible throughout the industry, and to bring laggards up into the pack and at least in sight of the leaders. Certain precise requirements are made, but as far as possible principles are stated and their application is to be made by regulations suitable for each mine or group of mines, taking into account the geological conditions, methods of mining, and especially the degree of mechanisation, which all differ widely even in Great Britain. The intention is by this means to increase the use and encourage the development of new machines and methods of winning minerals, with due regard for safety. More precise

definition of the responsibility of officials as required by the Bill should prevent mistakes such as led to the disaster at Knockshinnoch in 1950, and the loss of thirteen lives because a steeply rising heading was inundated by wet peat when it broached a bog. In particular the manager of a mine is put in supreme authority, made captain of the ship as it were, and subject only to instructions (which he may require to be confirmed in writing) through a defined chain of superior officers.

Another fundamental new requirement in the Bill is for the provision of alternative ways of egress from working places, to obviate a repetition of the recent disaster at Creswell Colliery, when eighty men lost their lives because a fire on a main intake airway blocked their only road of escape. Fire is a menace following very many accidents, some relatively slight in themselves, and it is the real killer as the aftermath of most explosions of gas underground. Many of the risks and dangers in mining may never be prevented entirely, but in respect of fire, prevention is certainly better than cure. For that reason the extending use of steel instead of timber props, and of steel arches for the support of roadways is highly valuable, although the practice of lagging the arches with wood is to be deplored because it has led to the spread of many fires. A wholly satisfactory substitute has yet to be found. The manager's obligations, in respect of ventilation, for example, the permissible contents of gas and dust in the air, and the amount of stone dust to be maintained on the floors of roadways as a deterrent to the spread of an explosion, and other requirements, are framed in accordance with the knowledge gained by much research and practical investigation to find the best means and conditions of their use to ensure safety without risk to health. Similar measures applying to the provision of adequate support, proper operation of haulage systems, maintenance of machines and other equipment, and above all to increase knowledge, discipline and good sense among all concerned, have led to great improvements in safety and health of miners. For many years now the number of mining accidents has declined steadily, and the total fatalities in 1950 were 493, as compared with 923 in 1940. The number killed by falls of ground was more than halved during that period, yet falls are still the major single cause of accidents and responsible for about 40 per cent of the total killed ; haulage accidents come next, accounting for about 20 per cent of the total. In the category of explosions and fires there has also been a real decline, although less regular for fairly obvious reasons. Thanks to the excellent design and construction of winding engines, combined with their skilled operation, and to modern knowledge based on research into the design of wire ropes, their maintenance and the causes of deterioration, major winding disasters are rare and relatively few accidents occur in shafts.

The growing importance of the mechanical engineer in mining generally was recognised by the appointment a few years ago of an inspector of mechanical engineering. The big reduction in accidents and other improvements referred to are of direct interest to many engineers other than mining men because they have proceeded in step with increased mechanisation throughout the mines. Until 1945 that applied chiefly to the use of cutters and conveyors at the coal face, and of belt conveyors on the roads. By 1950 there were 325 diesel-engined locomotives underground and the number is increasing rapidly. Moreover, new kinds of cutting and getting machines were being developed for use in conjunction with so-called snaking conveyors at the coal face. It was the introduction and development of such equipment that made it imperative to abandon traditional methods of support by rigid props of timber or steel. Instead, yielding props are used which serve the purpose better and are safer to use. Many of them depend on friction for the resistance they afford, and most of the designs produced are of Continental origin. The use of the alternative principle of hydraulic control first attracted the attention of a well-known British manufacturer and pioneer of hydraulic suspension for aeroplanes, when in 1945 he began to look for new fields. The self-contained manually operated prop he produced after three years' intensive development has now fully proved itself and is being supplied to the mines in very large numbers. It is used chiefly on faces worked with the new getting machines and their integral conveyors. The ease and speed with which the hydraulic prop is set and released and the uniformity of resistance it affords have proved highly valuable to safety as well as production. Once again we have proof that increased output by proper planning and equipment is conducive to higher standards of health and safety.

Obituary

SIR PHILIP WIGHAM RICHARDSON

It is with regret that we record the death of Lieutenant-Colonel Sir Philip Wigham Richardson, Bart., which occurred at his home at Weybridge on November 23rd. Sir Philip, who was in his eighty-ninth year, was born in Newcastle upon Tyne on January 26, 1865, and after completing his education at Rugby School and King's College, Cambridge, he joined the shipbuilding company which his father had founded at Low Walker on Tyneside in 1859. He was made a director in 1891 and continued to be a director after the amalgamation of his company with C. S. Swan and Hunter, Ltd., to form the shipbuilding and engineering company of Swan, Hunter and Wigham Richardson, Ltd. During his association with the company he travelled extensively in search of orders and continued to serve as a director after he retired from the chairmanship of the company, a position which he occupied from 1945 to 1949.

He took an interest in politics, becoming a Member of Parliament for Chertsey in 1922, and continued to represent that division until he retired from Parliament in 1931. His great hobby and lifelong interest was rifle shooting, competing at Wimbledon and Bisley for many years, and he was the author of several books on this subject. He served during the 1914–1918 war and for his services towards improving the standard of musketry in the British Army was appointed an O.B.E. in 1919. Two years later he was knighted and was created a Baronet in 1929.

H. R. BRETT

We greatly regret to record the death of Mr. Harold Russell Brett, which occurred, after many months of ill-health, at his home at Chipperfield, Herts, on November 24th. Mr. Brett, who was seventy-six, joined the staff of The Engineer in 1927 as London advertisement representative, and continued in that appointment until his retirement early in 1948. During his twenty-one years of loyal service to this journal, Mr. Brett made many friends amongst our readers and advertisers. They, with us, will long remember him with respect and affection.

LOUGHNAN ST. LAWRENCE PENDRED C.B.E.

A memorial Service for the late Loughnan St. Lawrence Pendred, C.B.E., will be held at The Queen's Chapel of the Savoy on Friday, December 11th, at 12.15 p.m.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A GREAT LOCOMOTIVE CLASS

Sir,—Mr. R. J. Doran, in a very able letter, published in your correspondence columns on November 13th, delineates the history of the G.W.R. " Saint " class locomotive now unhappily threatened with extinction unless efforts can be made to secure the preservation of No. 2920 " St. David." There is nothing that I feel competent to add to Mr. Doran's brilliant résumé of the " Saints " and their derivatives. However, I should like to add emphasis to the fact that it was the " Saint " class engine which embodied the outstandingly meritorious principles enunciated by Mr. Churchward and referred to by Mr. E. C. Poultney in his recent book, *Locomotive Development*, 1898-1948, as the keystone of the arch upon which all modern locomotives are designed. In this sense it would appear more important to preserve a " Saint " than a " Star." According to British Railways, the chief reason for not keeping a specimen of the " Saint " class locomotive is lack of storage space. If this is the only reason I should like to draw their attention to the fact that here in Malvern at the Wells station there is an engine shed which has remained empty for many years. Could not " St. David " be housed here until such a time as the promised Transport Museum materialises ?

L. F. H. Tandy

Malvern, Worcestershire,
November 23rd.

Sir,—In the Autumn of 1949 you allowed me to plead for the preservation of at least one Churchward 4–6–0 engine, either a " Star " or a " Saint," or both. It is difficult to add anything to Mr. R. J. Doran's excellent letter, except to endorse every word in it, without reservation.

Nearly four years ago it was announced that " Lode Star " would be reprieved and two years later the British Transport Commission agreed in principle to the establishment of a permanent transport museum at Nine Elms, and so there should be no difficulties as regards the matter of storage space. Two G.N.R. Ivatt " Atlantics," both locomotives of great historical interest, have been saved from the scrap-heap, but surely " Saint David " has a far greater claim to be preserved for posterity than either of these.

It is conceded that the boilers of the " Stars " and " Saints " are identical and developed from the design used for the " City " 4–4–0 engines. The latter class was the first to be provided with tapered boilers and high raised Belpaire fireboxes, which represented a very definite milestone in locomotive development in this country. An enlarged version of this boiler, carrying for that period the high working pres-

sure of 225 lb per square inch, became the Swindon Standard No. 1 boiler and was fitted to all the Churchward 4–6–0 express and, of course, the 2–8–0 freight engines.

However, it is in connection with front-end design that Churchward's name will for ever be associated. I refer to his pioneer work on cylinder proportions : long-lap, long-travel piston valves with well designed steam and exhaust passages, and the jumper blast pipe. For reasons which Mr. Doran has stated, the front-end design of the " Saint " is of greater interest than that of the " Star," and forms the basis of all that is best in present-day British locomotive practice, high-degree superheat alone excepted.

On several occasions in recent years, the engineering genius of G. J. Churchward has been publicly recognised. Some fifteen years after his death, the then President of the Institution of Mechanical Engineers, Captain (E) William Gregson, R.N.R., named one of the latest " Castle " class engines after the great locomotive engineer. In March, 1950, a paper was presented to the Institution of Locomotive Engineers by Mr. K. J. Cook, O.B.E., entitled " Churchward's Locomotive Development on the Great Western Railway."

In conclusion, I should like to mention a contribution by the late Mr. J. Clayton to the discussion on Mr. E. S. Cox's paper, " A Modern Locomotive History," in which the following words appear :—

" From what has been said, both in this paper and the discussion on it, one cannot overlook the great influence exercised over the modern steam locomotives of this country by the tradition and practices of G. J. Churchward, at whose feet sat, always admiringly, those whose names appear in the paper and in this note."

JOHN FOX

Hove, November 23rd.

GAS TURBINE AND DIESEL-ELECTRIC LOCOMOTIVES

SIR,—I read Mr. O. S. Nock's letter on this subject with great interest. I respectfully join issue with his arbitrary statement : " the gas turbine reaches its optimum efficiency range when working at full load." Whilst this may be true of the gas turbine engine at present employed in locomotives, it is a wholly untrue generalisation. One of the very attractive features about gas turbine power systems is that they can be designed to give their maximum efficiency (and a good efficiency at that) at, say, 20 per cent of full power, and this, as Mr. Nock will promptly appreciate, is of the utmost importance in connection with locomotives.

The fact is that there is no modern design of gas turbine at present installed in a locomotive and I very much doubt if much technology exists in any locomotive which has been embodied since about 1945.

In a very fast-moving art, the significance of this point is, of course, that any gas turbine locomotive which is to-day a novelty in the public eye is technically obsolescent.

PATRICK JOHNSON

Hampstead, N.W.3, November 17th.

BRITISH PLASTICS EXHIBITION.—The next British Plastics Exhibition is to be held at Olympia, London, from June 1 to 11, 1955. As in former years, a convention will be held concurrently with the exhibition. It will be the third British Plastics Exhibition and all sections of the industry will be represented, including raw material suppliers, manufacturers of moulding powders, synthetic resins, plastics sheeting, moulders and fabricators, manufacturers using laminated plastics and reinforced plastics, and manufacturers of moulding plant and other essential equipment. The exhibition and convention are to be organised, as before, with the full co-operation of the British Plastics Federation, by *British Plastics*, Dorset House, Stamford Street, London, S.E.1.

Institution of Mechanical Engineers

GENERAL MEETING

AT a general meeting of the Institution of Mechanical Engineers, which was held in London last Friday, November 27th, in conjunction with the Internal Combustion Group, two papers were presented : " Fuel Systems and Controls for Marine Gas Turbines," read by R. F. Darling, B.Sc., and " Main Propulsion Gas Turbine Set for the Oil Tanker ' Auris ',' read by B. E. G. Forsling. Engineer Rear-Admiral A. J. Hoare, C.B., chairman of the group, presided. The following discussion took place.

DISCUSSION

Sir Harold Roxbee Cox said that he was surprised when Mr. Darling said that " the aeronautical engineer tends to be obsessed by a desire to save space and weight at all costs, regardless of whether this is either necessary or desirable," and the speaker did not consider that to be quite the case. Weight was vital in aircraft engines and if 50 lb could be saved on the engine the weight of a passenger and his luggage would be saved, so that there was an incentive to save weight ; but it was not done at all costs.

Another point was that additional weight of material frequently did not mean additional safety, and some economy in the use of materials from all points of view was a good thing. Mr. Darling was right to put the matter of relative weight into perspective and indicated that it would be foolish to indulge in great expense and complication to reduce the weight of a marine engine by a few pounds in circumstances where simplicity, reliability and robustness were highly desirable. However, the weight of the machinery of the " Auris " at about 470 tons, would be worth reducing if possible.

With regard to the " Auris " gas turbine, he said it would be interesting to hear Mr. Forsling's view on what might have been gained in thermal efficiency if he had used a heat exchanger of considerably higher thermal ratio, for example, 75 per cent.

Dr. E. A. Watson, said that the sprayer or atomiser of the spill type had many advantages, the chief being that it provided large entry ports, relatively large orifices which would not get bunged up with dirt, while its one disadvantage was that the spray angle varied to a very wide extent with load. When designing a combustion chamber one endeavoured to fit the spray pattern into air flow pattern and it would be of interest to learn whether Mr. Darling had experienced trouble in his combustion chambers or whether he had been able to keep a sufficiently good compromise between the two flow patterns.

In the case of sprayer erosion he had similar experiences but the cause had been put down to solid particles being centrifuged out, going round and round and carving it away. Hardening of all the parts had provided part of the solution.

The drawings of the control system showed an ordinary solid piston, and Dr. Watson wondered whether that was an over-simplification, because he had found that with any normal form of piston sliding in a cylinder subjected to a continuous fuel pressure difference across it, it would gradually filter out particles of dirt, which would get in the faces and stick, so that he could foresee some emergency arising where the oil pressure failed and the spring did not move the piston to a safe position because the plunger was stuck.

The gas turbine discussed was of great interest, because it was the only gas turbine which Dr. Watson knew was operating satisfactorily with a ceramic lined chamber. For good combustion time, temperature and turbulence were necessary, and by using a ceramic lining it was possible to work at a much higher temperature. The aircraft engine designer could not use ceramic lining, but had to use metal lining, and often ran into trouble with combustion as a result of the air cooling methods used.

Ordinarily in a combustion chamber it was necessary to have a flame stabiliser in order to get a really intense combustion system, but it appeared in this instance that the air was put straight in, and went straight through the chamber. Would Mr. Forsling say whether it had been necessary to keep the flow circulation to stabilise matters or whether it was possible to use a simpler sort of arrangement. From the diameter of the chamber it appeared that the air jets had no appreciable radial velocity, and he wondered whether a good deal of mixing did not take place outside and around the bend.

Dr. A. T. Bowden, B.Sc., said that the characteristics of the " Auris " compressor were admirable and he could not recollect ever having seen a better surge line. It would be interesting to have details as to the entry conditions, in that guide vanes were likely to be a big contributory factor towards the very good surge condition. The bypass valve was an excellent feature, but unfortunately, it was usually necessary to deal with higher temperatures than those dealt with by Mr. Forsling. He presumed that air-packed glands were used, and asked if Mr. Forsling could give the order of turbine clearances used, any information on running troubles experienced before he got them sorted out, and what he finished up with in practice.

The ability to burn heavy fuel was attractive, and he thought that a contributory factor was the use of big chords for the turbine blade, and it would be useful to have particulars of the chords and pitch chord ratio which were used.

With regard to burning heavy fuel, it would be interesting to know whether the turbine was likely to suffer if put into tropical waters when both output and efficiency were likely to be reduced, and asked to have an idea of the order of output and the sort of efficiency which might be expected under tropical conditions of, say 85 deg. Fah.

Dr. D. M. Smith, F.R.S., said that he did not agree with Mr. Darling's views concerning temperature control and considered that temperature governing had a most important bearing even in marine gas-turbines. He commented on the remarkable overall performance achievement of the " Auris " set notwithstanding the comparatively moderate cycle conditions due to the high component efficiency of at least most of the components. That component efficiency had been obtained by the very generous design of the components, that is, by the use of a considerable number of compressor and turbine stages in relation to the duty and by the use of comparatively moderate blade velocities and substantial flow areas. It would be interesting to hear whether Mr. Forsling felt that his design was an optimum design from

the point of view of economy, or whether it would have been more economical to have dropped one or two stages and perhaps to have used slightly higher gas velocities, thereby sacrificing very little in component efficiency but getting an appreciably cheaper gas turbine.

It would also be useful to have more information in connection with the turbine flow coefficients. The flow coefficients showed little scatter in the case of the h.p. turbine and little scatter in the l.p. turbine at high throughputs but a great deal of scatter at low throughputs. Perhaps there was wide variation in speed ratio in the tests carried out at the lower throughputs on the l.p. turbine, whereas there would be little variation in speed ratio in the h.p. turbine and comparatively little at higher throughputs on the l.p. turbine.

Mr. R. J. Welsh, Wh.Ex., said that the most interesting feature in Mr. Darling's paper was the gearbox, because a good method of reversal was the chief difficulty that had held back the more widespread use of the marine gas turbine. He thought highly of the Pametrada scheme and desired to know whether it was in service and what results were being obtained. It would be interesting to know whether one burner had been changed during operations and whether there was danger of bad temperature distribution running with one burner in and the other out.

With regard to the question of weight, he agreed that in marine matters weight did not matter so much. Aircraft was designed for one flight and it was desirable to obtain the best results on that flight, whereas for a ship it was a question of the cost of the engine and fuel for its whole life. Therefore it was preferable to have more efficiency at the expense of weight.

Mr. A. Holmes Fletcher, B.Sc. (Eng.) said that one might deduce from the success of the B.T.H. turbine that the "large and heavy" adherents were completely vindicated and that weight saving was not worth while. However, space and weight questions were of a secondary nature and the primary consideration was the higher temperatures, which all agreed must be employed before the gas turbine became economically competitive with other prime movers and which were commonplace to the aeronautical engineer. He was conversant with combustion temperatures 200 deg. Cent. higher than those used in the B.T.H. turbine and was already working on higher temperatures with blade cooling. The aeronautical design principles were already established for running at those levels and he submitted that the marine engineer could not do better than follow them.

He agreed that 200 tons saving on the engines of a 30,000-ton tanker was insignificant but thought that on smaller vessels the improvement might be more valuable. For example, he defied Mr. Darling to fit 12,000 h.p. of "large and heavy" style gas turbines into the 140ft hull of H.M.S. "Grey Goose," which is what had been achieved with the aeronautical design of the Rolls-Royce "R.M.60" engines.

One of the more expensive pieces of equipment in the higher temperature engine would probably be the heat exchanger, and one wondered whether Mr. Darling had considered that when he recommended the turbine cycle with intercooling and heat exchanger as being the most suitable for future development. The intercooler reduced the dimensions of the following compressor so that its efficiency might suffer and brought in possible troubles from condensate erosion. The heat exchanger became valueless if intercooling were not incorporated in a high-compression cycle. Both devices introduced pressure losses.

As a matter of interest he had worked out the probable overall efficiency of a turbine using components as designed by Mr. Forsling, comprising two compressors in series at 3/1 compression ratio each, three turbines, and no intercooling or heat exchange. At the same combustion temperature that set showed some improvement over the figures given for the B.T.H. engine, and for a temperature of 727 deg. Cent., which should still give an adequate service life, the efficiency was something like 30 per cent better.

A further important quality conferred by the use of aeronautical principles was that of flexibility. So far, of all the gas turbines installed in ships only the "Grey Goose" with Rolls-Royce R.M. 60 engines relied on the main engines for manœuvring. All the others had either petrol or diesel reciprocating engines for that duty. Had the designers of the B.T.H. and other turbines any doubts about their units withstanding the sudden and frequent temperature changes involved in those operations ?

V.P. propellers had an important advantage, in that for manœuvring the engine's throttle could be left in a predetermined moderate power position and all changes of speed and direction obtained by altering the propeller pitch, so cutting out the sudden variations in temperature which could act in such a destructive way on the gas turbine unit.

He asked for information about the gas turbine's sensitivity to ambient temperature. Mr. John Lamb's recent paper on the "Auris" suggested a 30 per cent reduction in power for a 34 deg. Fah. rise in air temperature. Would that be dealt with by designing future installations for tropical power and providing a limiting device to maintain the output at that figure, or would the shafting and gears be designed for full Arctic capabilities and the 10 per cent slowing of the ship in warm waters be accepted ?

Mr. I. G. Bowen said that with regard to the preference expressed for a bifuel system, the reasons given did not appear to be valid. The ability to pump cold fuel oil at start-up was a function of pipe diameter as well as viscosity and a normal 1500 secs. Redwood I at 100 deg. Fah. grade had been handled successfully on the "Auris." Given the ability to pump the cold oil, the design shown in the paper then allowed for circulation to bring the oil up to the temperature.

There was an advantage in operating a spill burner at constant supply pressure, but that entailed the use of a pump of capacity some 20 to 100 per cent greater than the maximum flow required of the burner. The design incorporated a second spill return, which was normally open. If the area of the leak-off aperture in the operating piston was appreciable, the fuel pump capacity had to be even greater. Would the author indicate whether constant fuel supply pressure was used and what the overflow factors were for the control and shut-off spill lines ?

On the question of atomiser erosion, the phenomenon had been experienced on three other installations also using spill atomisers, and the speaker submitted an explanation for Mr. Darling's consideration. At light load on a spill burner the air core was probably parallel and was nearly coincidental with the output orifice diameter. The forward velocity, therefore, was low in the vicinity of the cone. It occurred to him that solids might be trapped in that region and might rotate at an equilibrium radius rather like a cyclone.

The use of a spill system in conjunction with solid fuel additives involved the passage of solids through the main pumps. To avoid that state of affairs a "once-through" sprayer, used in conjunction with an additive pump, was the only alternative. It would be interesting to have the author's experience on the effect of solid additives in pump wear.

Could not Mr. Forsling consider making a smaller exchanger or else a more efficient one for the same size ? If the tubes were reduced from $1\frac{1}{16}$in O.D. to $\frac{1}{2}$in. O.D. for the same thermal ratio the heat exchanger would shrink to 40 per cent of its present volume, or, if the same volume of exchanger could be tolerated, the thermal ratio could be increased from 50 per cent to 65 per cent. This would cut the fuel bill of the gas turbine by about 10 per cent.

Captain (E) H. Farquhar Atkins said that the heavy steam turbine type of casing and rotor used in the "Auris" and by Pametrada asked for distortion troubles and had resulted in seized rotors, despite elaborate precautions in heating and cooling. Quick starting was one of the prime attractions of the gas turbine to the Navy.

Marine engineers tended sometimes to consider that weight equalled strength, and to think that the thicker a casing the greater its factor of safety and its reliability and the longer its life. In a gas turbine where at present pressures were low but temperatures were high, the stress in the casing during a cold start would be increased by making it thicker. A light inner casing and an outer pressure casing well insulated from the heat and air cooled would allow lighter scantlings and reduce distortion problems.

Was a shipowner really prescient if he insisted on an engine life of twenty-five years ? The gas turbine was still developing rapidly. The "Auris" set, fine achievement though it was, already neared obsolescence, and he suggested that progress would be fast enough to justify new engines every ten years. He placed simplicity as the first requirement of a marine gas turbine control system ; simplicity achieved by fitting as few automatic controls as possible and depending on the engineer for such matters as keeping within the maximum temperature permissible.

Mr. A. W. Pope, B.Sc., asked if Mr. Forsling could say more about the compressor, what axial velocity was it designed for and what was the staggering of the blading. On the question of engine life, he suggested that one should consider replacing the first stage turbine wheel and blade more frequently than the main engine. If the idea were accepted of replacing the disc and blade after, say, five years' running, it would be possible to get a much more highly rated engine which was smaller and more economical than if the whole engine had to be derated for twenty years' life for that one component.

Mr. G. B. R. Feilden, M.A., said with regard to Mr. Darling's proposal to use multiple combustion chambers with mixing chambers following, Mr. Feilden's company started their first gas turbine with twin combustion chambers but they were found to be very difficult and the company had gone over to the single chamber. There must be a limit to the size of combustion chamber, but he thought that there was a great deal to be said for building bigger single chambers.

Turning to Mr. Forsling's paper, he joined issue on the question of heavy versus light construction. It was mentioned that it was normal practice to allow about one hour from lighting-up before the load was applied, but with the lighter design it was

possible to construct a turbine with efficiencies quite as high as those of the engine under discussion which would accept the load in a short time. His company had recently carried out a test in which a set was started up from cold and put on full load in two minutes. The key to that particular operation was that the first minute was spent in going from stationary up to idling, during which the blades got over by far the most acute temperature change. After that the load could be applied very rapidly.

Mr. R. F. Darling, in reply, said that when he spoke about aeronautical engineers saving weight at all costs he meant by implication that they did so when they started to dabble in the marine field. He had the greatest respect for aeronautical engineers—when they stuck to aeronautical engineering. He agreed with Captain Atkins that so long as the Government were prepared to spend millions on the development of aero engines, those in the marine field should take such advantage as related to their problems.

Mr. Holmes Fletcher had defied him to put a 12,000 h.p. engine into the "Grey Goose." He would not dream of doing so. Mr. Holmes Fletcher was dealing with a naval ship which required a naval engine and was asking him to put a marine engine into that naval ship. He would no more think of doing that than of putting a naval engine into an aeroplane.

With regard to the question of high temperature used in aircraft engines and efficiency, he had never noticed that thermal efficiencies in aircraft engines were particularly good. In fact, high temperatures were used in order to get moderately good efficiency and keep the size down. It came back to the fact that one could not argue very far from aircraft conditions—specialised conditions—to Merchant Navy conditions which were again very specialised, but in a different sense.

Mr. Pope had raised a point concerning the desirability of changing the first stage turbine wheel at intervals, and that was a feature which did appeal to the author. It was, in his view, one of the few good ideas in the engine put forward, and it was a pity that the designer did not pursue it further and work out the extra amount of efficiency he could get, how much money he would save, and how much against that it would cost to replace the turbine. It would, of course, require a lighter construction of turbine.

That led on to the question of weight. It was the sort of argument which went on forever and ever, but those concerned at Pametrada did not question the fact that if the weight were reduced in general it helped to make the engine withstand a greater rapidity of temperature change, and so on. It was, however, very difficult to reduce the weight without reducing component efficiencies.

Mr. B. E. G. Forsling, in reply, assured members that gas turbines were not made any heavier than they need be. There were various reasons why weight could not be cut down. The aircraft engine was short whereas the marine engine was fairly long, and that long engine had to be supported, and an underbase had to be provided which meant that a fair amount of scantlings for supporting the engine were required. If one went for high component efficiencies the high temperature was saved for other purposes. If it were possible to maintain the present design or work in higher temperatures with little sacrifice in efficiency, a better machine would result; but if in order to go up to higher temperatures it was necessary to sacrifice turbine efficiency, it was another matter.

East Coast Sea Defence Works

No. I

A vast programme of constructional work has been in progress in East Coast areas to make good damage caused by the storm and tidal surge on the night of January 31st last. This work is being carried out principally by a number of River Boards, and much of it has now been completed or reached an advanced stage.

SINCE the catastrophic storm and tidal surge which occurred in the North Sea on January 31st of this year, reconstruction of sea defences along the East Coast of England has been undertaken on a large scale, and remarkably rapid progress has been made; generally speaking, the repair and reinstatement works have, by now, reached an advance stage of construction or have been completed. A figure of very approximately £20,000,000 has been spent on these works, and some of the river boards have constructional programmes extending into next year for their completion. But as a result of the progress which has been made already it can be asserted that the East Coast sea defences are now generally in a better condition than for many years, probably better than ever before,

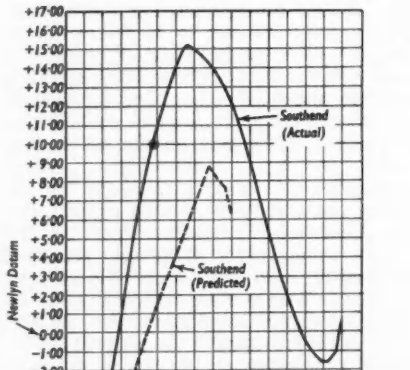


Fig. 1—Tidal Surge at Southend

along substantial stretches of coastline. In the ensuing sections of this article we give a brief description of these achievements, following the East Coast through the areas of the various river boards which have been responsible for them, namely the Hull and East Yorkshire River Board, the Lincolnshire River Board, the Welland River Board, the Great Ouse River Board, the East Suffolk and Norfolk River Board, the Essex River Board, and the Kent River Board. In some places, particularly the built-up areas, local authorities are responsible for the sea defences, and in particular along the Norfolk coast various local authorities have carried out important work, as well as the river board.

Before proceeding with this account, however, we may briefly note the meteorological conditions on the night of January 31st last, which caused such extensive damage. As Fig. 2* shows, a deep depression had moved from the Shetlands (where it had caused exceptional gales, with wind speeds well over 100 m.p.h., and much damage in Scotland) south-eastwards until its centre was close to Hamburg. Winds of gale force (the force of the winds on the Beaufort scale is shown on the diagram) swept down the North Sea from north to south during this period. The converging shape of the North Sea, with the restricted opening of the Straits of Dover at the south, causes a piling up of water under these conditions, and in fact the tidal surge then experienced was estimated to be from 6ft to 9ft above the predicted height. In addition, the coasts facing north were buffeted by waves of the kind normally experienced only in the Atlantic ocean, for the "fetch" of the waves was from the Arctic ocean right down through the North Sea. As an example of the magnitude of the surge, Fig. 1 shows its effect at Southend. It will be seen that the maximum surge is about 9ft, but it occurred nearly two hours before high water, so that maximum tide was only about 6ft above the predicted level. The predicted level shown on Fig. 1 is 8·8 O.D., which is rather below the mean spring tide level; the maximum spring tide of the year at Southend has a predicted high water of +10·9 O.D. Throughout this article various examples of predicted and actual levels will be given, but we will make no further remarks on this complicated question, confining ourselves to a straightforward description of the new works, for the more controversial issues involved will doubtless be thoroughly discussed at the conference on the East Coast floods which is to be held at the Institution of Civil Engineers later this month. A general appraisal of the situation was, however, given in a leading article in THE ENGINEER of February 13th last.

The most common form of coast protection along the East Coast is the clay bank. Failures in such banks, to touch on another somewhat controversial issue, were caused, it is generally considered, largely by overtopping, followed by slips and scouring out of the landward side of the bank. But there were other causes as well, principally the action of waves in breaking up the top of the bank, and in some particular cases, other causes, such as the building up of pore water pressure under the heel of a bank where the underlying materials permitted this action to occur. Failures were, of course, also experienced in concrete sea defences, and much damage was caused by the destruction of sand dunes.

The emergency works which were undertaken immediately after the storm will not be described to any great extent in this article. The importance of this work, in closing breaches with sandbags or other filling material, and by other hastily applied methods, should not, however, be overlooked. In many cases it was the promptness and effectiveness of those early and strenuously applied remedies which assured the success of the more substantial works described below. The Armed Forces gave no little assistance at this stage. As a typical example of such work we would refer the reader to an account given in THE ENGINEER of March 27, 1953, of the emergency works carried out by the Eastern Region of British Railways; in the latter part of that article there is a description of the closing of a breach near Benfleet, which may be regarded as typical of many other examples of such work.

As regards the civil engineering works themselves, it should be borne in mind that very rapid progress has been made, which reflects considerable credit on the engineers' and staffs of the various river boards and contractors who have been involved. Although this aspect of the work is not stressed in the ensuing description, the various figures given of the works completed will, we think, speak for themselves. The necessity for making an immediate start with the new works and completing them rapidly has meant that in most cases well-tried methods of construction have been utilised, making use of readily available materials and plant.

Yet another aspect of the work which is not emphasised concerns the clearing and reinstatement of numerous water courses in areas close to the sea. Many such watercourses were clogged

* A fuller description of meteorological conditions at that time is given in *The Meteorological Magazine*, No. 970, Vol. 82, April, 1953, published by H.M. Stationery Office, from which Fig. 1 has been reproduced.

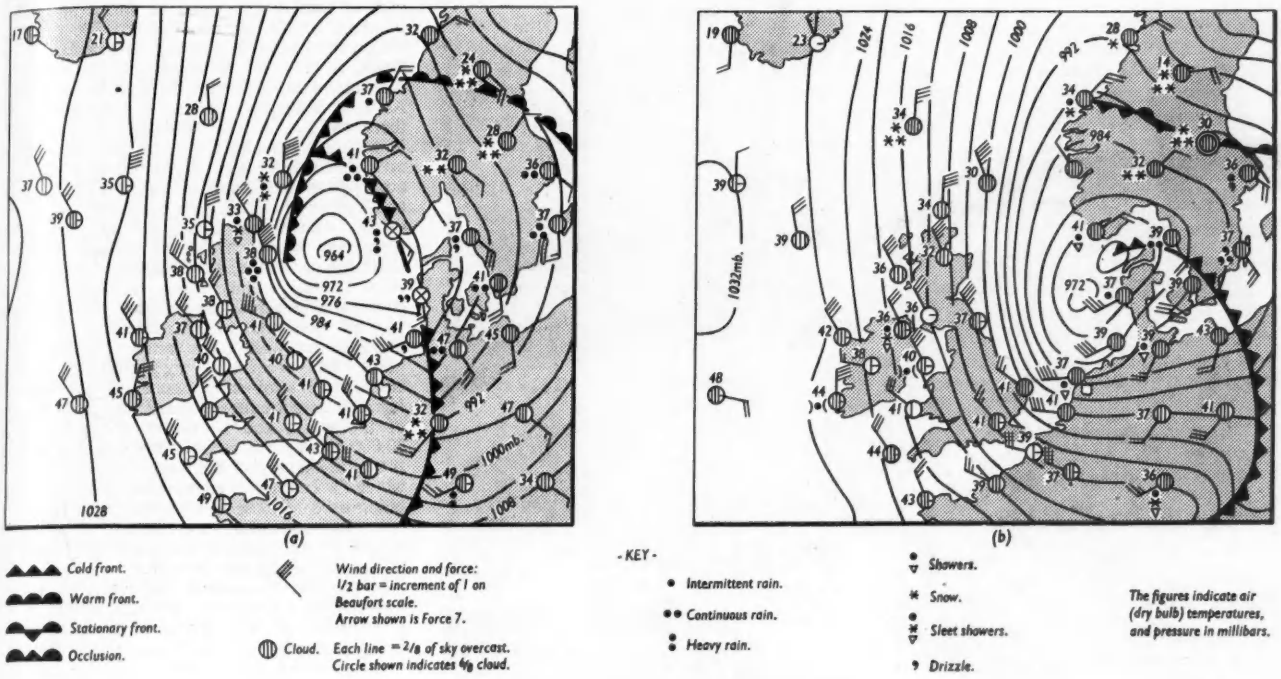


Fig. 2—Meteorological Conditions on January 31st

with sand or debris, and no small effort has been expended in getting them in good shape again.

The Yorkshire Coast

The tidal surge was felt most severely in the southern part of the North Sea, on the East Coast of England and on the Dutch and Belgian coasts. Further north it was not quite so severe. A certain amount of damage was caused in the estuaries of the Wear and Tees and some remedial works have been carried out on the embankments there, but not to the same extent as has been necessary further south. Most of the Yorkshire coast is formed by cliffs, and the first example of serious flooding was in the area of the Hull and East Yorkshire River Board, where tracts of land, along the north bank of the Humber, lying below the level of H.W.O.S.T., were inundated. The coastline under the board's jurisdiction extends southwards from Flamborough Head, and consists of clay cliffs all the way down to Easington, where a clay bank was badly breached and the land behind it flooded. The clay cliffs, although they are being eroded at a rate of 1 yard to 3 yards annually, prevented other than minor damage. Along the north bank of the Humber there were serious breaches in the banks and about 5¼ miles of bank have been rebuilt. About 4000 acres of land were flooded; but it is sparsely populated agricultural land and there were no casualties, other than to the livestock on the farms.

Some further works have been necessary to the west of Hull, in repairing breaches in the Humber banks (some industrial property was flooded here) and several lengths of river bank along the course of the River Hull are being heightened and strengthened. The docks at Hull suffered only minor damage. About three-quarters of the area of Hull lies below H.W.O.S.T. level and along the course of the River Hull there is low-lying ground for about 20 miles upstream. All of this land relies on the dock walls at Hull and the embankments along the River Hull to protect it from flooding. There was slight flooding last January, due to overtopping, and after the flood it was found that the banks had slumped in a number of places.

A typical sequence of operations in building the new clay banks along the north shore of the Humber is shown in Fig. 3. The existing bank, as shown at stage 1, was standing perhaps 2ft or 3ft below its pre-flood level, and the back of it was first stripped of topsoil, sand, &c., and cleaned down to give a good clay face. The various stages of the work were carried out successively on 30ft lengths of the bank. Two bulldozers were used in the first stage, and a bulldozer, or alternatively a small excavator, in the second. Two bulldozers were then used for stages 3 and 4, and a bulldozer was used to consolidate the top of the bank in stage 5, but an excavator was used on the roadway at this stage to handle the clay from the drain to the top of the bank. In the last stage a jubilee track was laid along the top of the bank to transport the stone pitching. In fact, the top level at present is +16 O.D., although the width of the bank is as shown, so that it would be a simple matter to increase the height to +18 O.D. at any time, should that measure be required.

The six stages shown were worked out before construction started, and one or two further points should be explained. A sand "lens" is shown built into the bank. When the work was started there was a shortage of good clay, and the depth to which a borrow pit could be excavated was limited, as the clay below the top crust was very soft. The sand lens was found to be without objection from the soil mechanics standpoint, for it was entirely surrounded by clay, clay "cross walls" being built at intervals for the full cross section of the bank. In fact, the sand lenses were only used for a short length, for the supply of clay became easier as the work progressed. Also, the clay became firmer after the first lengths had been constructed, and bulldozers were used in the fifth and sixth stages, instead of an excavator, only the final trimming

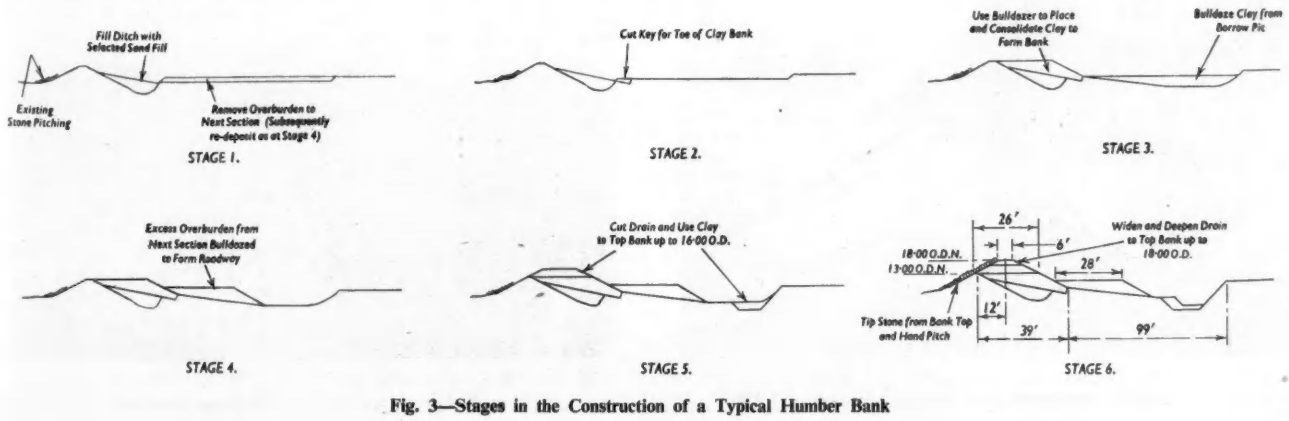

Fill Ditch with Selected Sand Fill
Existing Stone Pitching
Remove Overburden to Next Section (Subsequently re-deposit as at Stage 4)
STAGE 1.
Cut Key for Toe of Clay Bank
STAGE 2.
Use Bulldozer to Place and Consolidate Clay to Form Bank
Bulldoze Clay from Borrow Pit
STAGE 3.
Excess Overburden from Next Section Bulldozed to Form Roadway
STAGE 4.
Cut Drain and Use Clay to Top Bank up to 16·00 O.D.
STAGE 5.
26′
6′
28′
12′
39′
99′
18·00 O.D.N.
13·00 O.D.N.
Widen and Deepen Drain to Top Bank up to 18·00 O.D.
Tip Stone from Bank Top and Hand Pitch
STAGE 6.

Fig. 3—Stages in the Construction of a Typical Humber Bank

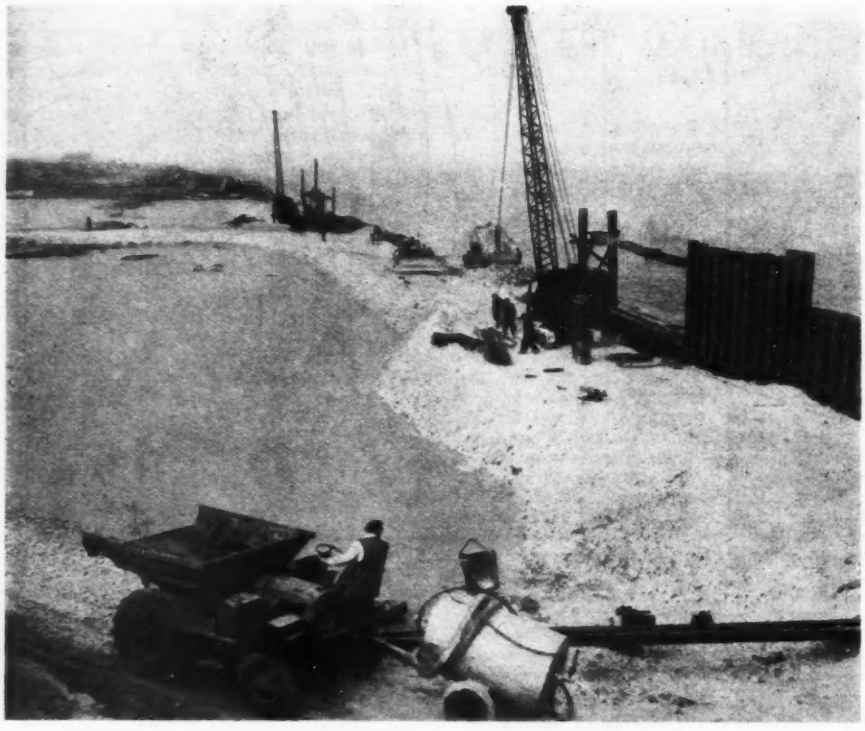


Fig. 4—Closure of Breach near Sutton-on-Sea

of the drain then needing an excavator. But when stages 5 and 6 were built with an excavator a light machine with a long jib but small bucket capacity was required.

A number of ancillary works—culverts and small bridges—were also constructed. The banks will be seeded next spring, to give the customary wave protection which grass affords. An interesting detail of the work has been that the various gangs were directed from the contractor's office by "walkie-talkie" radio sets. Along this remote 6 miles of coast some simplification and improvement of the supervision of the work was thus possible.

The breach in the sea bank at Easington was repaired by bulldozing sand and clay back into position, but in this case a new bank has been formed behind the line of the old one, as its north end is in danger of being outflanked by erosion of the clay cliffs which end at this point. The new bank is built to a top level of +19 O.D. and a top width of 10ft; the general ground level throughout its length is about +7 O.D. The bank merges with the +19 O.D. ground contour, where that contour swings inland from the end of the cliffs, about 350ft back from the end of the cliff face. The new bank is about 3200ft long and runs in a straight line to join the old bank at its south end.

Generally speaking, it is thought that the tides rise higher in the Humber estuary than on the coast, but on the night of January 31st the indications were that the reverse was true. The still water on the coast was thought to be at about +16 O.D., with wave heights of the order of 20ft. (trough to crest), but in the Humber estuary the waves probably did not exceed 3ft or 4ft.

The works described above were carried out under the direction of the engineer and clerk of the Hull and East Yorkshire River Board, Mr. G. Ellison. The main contractor was Richard Costain, Ltd., and the total cost of the works was about £350,000.

The Lincolnshire Coast

The stretch of coastline between Mablethorpe and Skegness has been the scene of very considerable constructional activity throughout the summer months. Grievous damage was suffered along this coastline, which included the Acre gap, a breach 450 yards in width and other breaches of similar magnitude. The coastline within the jurisdiction of the Lincolnshire River Board is 68 miles in length, of which the sea defences of 34 miles were damaged or destroyed. An area of about 24,000 acres was flooded and there was loss of life and damage to property; in Mablethorpe and Sutton-on-Sea sand blown or washed from the neighbouring dunes had accumulated in the streets to depths of 5ft or 6ft, and had to be cleared with bulldozers before the various contractors could get to their sites. Emergency works, following initial large-scale sandbagging, involved the tipping of large quantities of fill, mainly stone or slag, to form embankments across the breaches, or the driving of steel sheet piles to close breaches or protect damaged sea walls from further collapse. The piling was frequently supported by similar embankments of filling material. A fleet of lorries was continuously employed at this stage of the work, and a rate of emplacement of 30,000 cubic yards of fill a day was maintained. A typical example of this work is shown in Fig. 4, where the emergency embankment and steel sheet piling used to close a large breach at Bohemia, near Sutton-on-Sea, are shown under construction; the access embankment in the middle of the illustration may be noted.

As to the permanent reinstatement works, repair of clay banks has been carried out on the south coast of the Humber estuary, the banks being generally faced with stone pitching, laid in large panels formed by reinforced concrete beams, and jointed with bituminised sand. Proceeding southwards, clay banks have been built along lengths where the sand dunes which formed the coast protection before the storm have been eroded away altogether or to such an extent that they no longer give much protection. Where the dunes were much wider, although they suffered damage, sufficient width remains, and the new works have been limited to the emplacement of brushwork to accumulate wind-blown sand. These more substantial sandhills extend southwards to Mablethorpe. South of Skegness a small breach was repaired near Gibraltar point on the north coast of the Wash. The bulk of the new work, however, lies between Mablethorpe and Skegness, where several interesting forms of construction have been employed.

A noteworthy point about this work is that everywhere the emergency protection has been incorporated in the permanent works, and nowhere has it been rendered redundant by the construction of permanent sea defences. The embankments of filling material have formed a base to carry a stepped or sloping sea wall, where reinforced concrete has been used, with the slope of the wall formed on the seaward side of the embankment, and a wave wall at the crest. The steel sheet piling has been incorporated generally as a cut-off at the toe or along the line of the back of the wall. Three typical examples of the construction along this stretch of coastline are shown in Fig. 8; they

Fig. 5—Construction of Sea Wall at Acre Gap

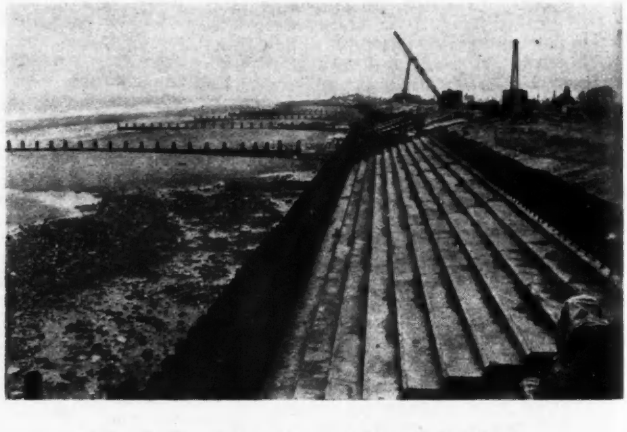


Fig. 6—Construction of Stepped Wall near Sandilands

will be referred to in more detail in the ensuing description.

The north end of the sea wall at Mablethorpe, where it joins with the dunes mentioned above, consisted of an old concrete stepwork wall. The steps were not reinforced and were thus easily damaged. The reconstruction work provides the first example of a principle fairly generally applied along this length of coast in the reconstruction work. The damaged stepwork and the fill placed as emergency protection were consolidated and the slope trimmed to form the base of the new wall. Grouting holes were left in the new stepwork or drilled in any old work which remained intact, and on completion grout was injected to fill any cavities remaining in the filling materials.

The next form of construction encountered to the south of the new stepped wall is illustrated by a typical cross section in Fig. 8. A blinding layer of concrete was first laid on the slope of the settled fill. Steel sheet piling was driven along the toe of the embankment and surmounted by a reinforced concrete capping beam. This beam was tied into cross beams at 45ft centres, extending to the top of the bank, where they, in their turn, tied into a wave wall built above the crest of the bank. The wave wall is carried on a substantial concrete anchor block. The spaces between the reinforced concrete grillage thus formed on the seaward slope of the embankment are covered with precast concrete slabs. The slabs form a surface which is flexible enough to take up a certain amount of movement due to settlement of the embankment ; they are rather larger than

Fig. 7—Reinforced Concrete Sea Wall Near Sandilands

the slabs generally encountered for such work, being 3ft 7in by 3ft 7in by 10in in size. The joints are sealed with a bituminous mixture consisting of sand, asbestos and bitumen. The wall is completed by an impermeable roadway (adequately drained) on the crest of the bank, and by a second line of steel sheet piling driven during the emergency period on the landward side of the crest. This second row of piling was considered necessary on some more exposed sections and, in fact, had been driven to close two original breaches along part of the length of this wall. The slope of the wall varies between 2 : 1 and 3 : 1, following the contour of the embankment.

This type of construction extends for 2¼ miles from the end of the stepped wall, until it joins a length of sea wall which was built only a few years ago and extends for 1200ft. The Acre gap—one of the biggest breaches on the Lincolnshire coast—extended between the south end of this wall to the north end of a similar length of modern wall, about 1500ft long, on the south side of it. These two lengths of recent construction suffered comparatively light damage and have been repaired where necessary, and grouted, as described for the new stepped wall, to take care of any movement of their underlying fill.

One particularly interesting observation was made on one of these walls. The bull-nosed wave wall was cracked through at its narrowest point (i.e. at about the middle of the concave curve) by the force of the waves. The load necessary to

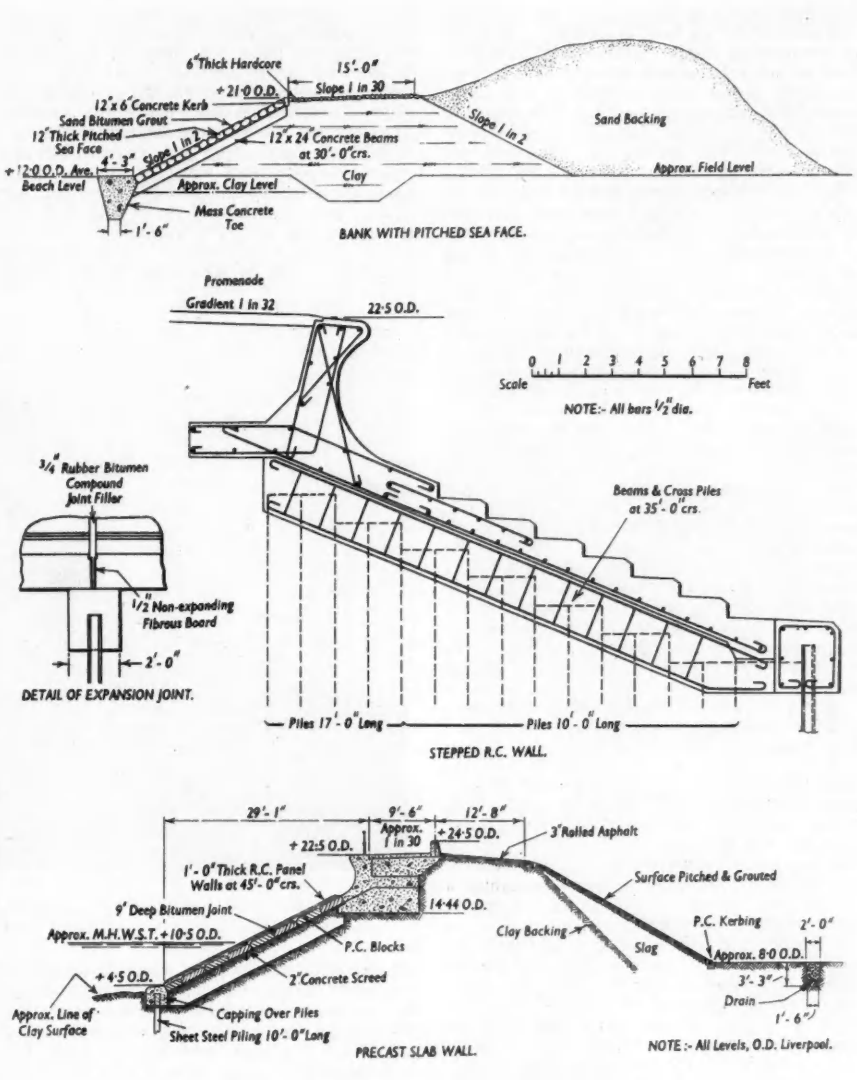


Fig. 8—Typical Sea Walls on the Lincolnshire Coast

cause such a fracture was estimated, and it was then deduced that the minimum force exerted by a wave, in order to cause such a fracture, was 1½ tons per square foot. The waves had been estimated to have a maximum height from trough to crest of 13ft. The still water height was 15·8 O.D. (Newlyn), 6ft 6in higher than the predicted level.

The Acre gap extended for a quarter of a mile and the flooding through it penetrated inland for 4 miles. The old sea defences consisted of some timber cribwork in front of sand dunes, all of which was completely destroyed. The sea wall now being completed across the gap is as shown in Fig. 8, and of the design we have just described. There were, however, one or two differences in the method of construction. Steel sheet piling was driven across the gap, in front of the emergency bank, to form a cofferdam. The bank was then bulldozed forward so that the toe of its trimmed slope coincided with the line of piling. The wall was then constructed within the cover of the cofferdam and the cofferdam piles were finally burned off, the bottom half remaining as the cut-off for the toe of the wall and the burned-off top part being employed as toe piling on another stretch of the work. A typical length of this wall is shown in Fig. 5.

Proceeding southward from the works described above, a critical length of 1800ft at Sandilands, where the old stepped wall completely collapsed, has been rebuilt behind the shelter of a steel sheet piled cofferdam as a reinforced concrete stepped wall, as shown in Figs. 6 and 7. Then follows a length of some 1300ft of similar construction. These extensive concrete works are then followed by new clay banks for the remaining 4 miles to Chapel point ; the sand dunes in this area were almost completely washed away, and flooding extended back to the so-called " Roman bank." This second bank has also been repaired and heightened. At Chapel Point the concrete sea defences are being reinstated and there is again a new clay bank to the south of the Point, and also a 600 yards length of tipped stone fill where there was a major breach at Trunch Lane. Following this length, a further mile to Vickers Point is completed by a concrete stepwork wall, which suffered considerable damage, and is being largely reconstructed. Between Vickers Point and Skegness there was again substantial damage over the whole of this 2-mile length, and a reinforced concrete stepwork wall is being built on the stone fill placed shortly after the emergency. This wall is shown in cross section in Fig. 8, but before giving some further details of construction the clay bank construction used to the north of it will be described.

The cross section in Fig. 8 shows a typical clay bank construction, in one of the more exposed stretches where this type of work has been built. The seaward face, as may be noted, is divided into bays by reinforced concrete beams, and the panels thus formed are faced with slag pitching and the joints grouted with a sand and bitumen mixture. On the less exposed lengths the clay bank has been left without a facing, and is expected to act as a core for the formation of a dune of wind-blown sand. Along substantial lengths of coast the Roman bank forms a second line of defence, and it has been strengthened and

heightened to a top level of +18 or +19 O.D. The level of the sea bank is generally +20 O.D., as the drawing shows. Cross banks have been built at intervals between the two lines to limit the extent of any possible flooding, and access roads built to the sea bank. There are extensive borrow pits in various places behind the banks, but in some cases the top soil of a field was stripped and then a uniform thickness of clay taken and the top soil reinstated. Much of the clay was moved to the bank by scraper, but draglines did most of the shaping work on the bank.

The stepped wall at Skegness, shown in cross section in Fig. 8, is typical of the various lengths of stepped wall which have been mentioned. Its cost is about £40 per foot run. Steel sheet piling forms a cut-off at the toe and cross walls of steel sheet piling have been formed at 30ft centres. The toe piles and the cross piles are both surmounted by reinforced concrete beams. The stepwork is substantially reinforced, the reinforcement being carried into the wave wall and into the promenade behind the wall. In practice the excavation for the toe of the wall has been thrown up on the beach to give some protection in rough weather whilst construction is in progress. The piling is pitched and driven by an excavator standing on top of the bank. The stepwork is all formed in one operation, with a single shutter covering a length of wall of about 30ft and extending from the toe beam to the bottom of the wave wall ; the concrete is placed by pump from a central batching plant. The rate of progress achieved is about 70ft of wall per day.

The whole of the works on the Humber banks and the North Sea Coast of Lincolnshire have been under the direction of Mr. F. H. Tomes, O.B.E., M.I.C.E., Chief Engineer of the Lincolnshire River Board, and the Board's permanent engineering staff augmented by engineers loaned by other river board and other public authorities, and other engineers engaged for the period of the works. In Mablethorpe and Sutton-on-Sea, however, the assistance of Wilton and Bell and C. H. Dobbie, acting as joint consulting engineers, has been obtained for the design and execution of this particular section of the work. Some sections of the new defences have been executed by direct labour, but the major part has been carried out out by contractors. Early contracts were let on a fixed fee basis. The later contracts were let out to tender in the usual way. The emergency works, which, as will be recalled, included the building of big banks of stone or slag filling, cost about £2,500,000. The subsequent reinstatement works have, up to the present, cost about £2,500,000 and are nearing completion.

The following is a list of the contractors engaged on the Lincolnshire works :—William Moss and Sons, Ltd., W. J. Simms, Sons and Cooke, Ltd., Dowsett Engineering Construction, Ltd., Tarmac Ltd., The Mitchell Construction Company, Ltd., Gee, Walker and Slater, Ltd., Jack Branch, Lehane, Mackenzie and Shand, Ltd., Holloway Brothers (London), Ltd., A. E. Farr, Ltd., George Wimpey and Co., Ltd., Sir Robert McAlpine and Sons (Midlands), Ltd., The Butterley Company, Ltd., H. O. Andrews, Ltd., W. G. C. Hammond, Ltd.

(To be continued)

Extensions to the Works of Bakelite Ltd.

A LARGE new plant for the production of different kinds of polyvinyl and copolymer resins has recently been completed at the Aycliffe works of Bakelite, Ltd. This plant is an important addition to the firm's productive capacity. It forms the second phase of an extensive building programme, the first stage of which was completed about five years ago and was described in our issue of July 30, 1948. The works are situated on the site of a disused Government ordnance factory and for the initial buildings a site of 35 acres was acquired. For the new plant a further 47 acres of land was acquired and there is sufficient land available for extensions at some future date should they be required.

The new polymer plant consists essentially of low-temperature storage tanks, mixing tanks for monomers, polymerising equipment, grinding and screening plant and weighing and storage facilities to handle the final product. Initially, the plant is being used for the production of vinyl chloride-acetate copolymer of the " Vinylite Vynw " type, which will be sold under the company's trade mark as " Vybak Vnyw." This is a general-purpose resin which is stated to give easier working, fluxing and plasticisation than straight polyvinyl chloride resins without loss of mechanical and electrical properties.

The plant is of entirely British construction and, as can be seen from the photograph we reproduce on this page, a very large proportion of the equipment is built in the open with no form of housing or overhead protection. Services built integral with the plant include water circulating equipment and water storage, fire-fighting equipment and refrigeration and nitrogen units. The pumps for water circulation and fire-fighting purposes are housed in a single-storey building at one end of the plant. The refrigeration and nitrogen plants are laid down in an adjoining building at the head of the storage and processing plant.

Vinyl Resin Plant

Nitrogen is used in the plant as a safety measure to form an inert blanket in all pieces of equipment in which vinyl chloride is either stored or polymerised. It also serves to keep the vinyl chloride free from such instruments as pressure gauges and containers where blockage by the polymer would result if the monomer was not excluded. An ammonia compression refrigeration plant supplies refrigerant in the form of calcium chloride brine to the reaction and storage areas in the plant.

The raw materials, such as vinyl acetate and vinyl chloride, are delivered to the site in road tankers and are unloaded by means of pumps or by gas pressure into pipelines leading to storage tanks. From these tanks the materials are pumped into adjoining weigh tanks used to prepare for the polymerisation system feed mixtures of varying compositions corresponding to the resin required. The polymerisation system is designed to manufacture resin by any of the well-known techniques, and its arrangement gives the flexibility necessary to cover a wide range of copolymer products. Manufacture is controlled at all stages by servo-mechanisms and a complete set of recorders and control instruments is arranged in a control room in the main building at the end of the plant. The extensive use of instruments and servo-control mechanisms enables the plant to be operated by a very small labour force.

Resin made in the polymer plant is conveyed straight into the main building where it is finally dried, screened and blended before being packed in bags for despatch. This building can be seen in the foreground in the photograph of the plant which we reproduce.

The resins produced in this new polymer plant are either converted in the works into moulding or extrusion compounds or sheet, or despatched to customers who do their own conversion. Initial compounding for both moulding and sheet materials follows the same course and is done by passing the material through ribbon pre-blenders, Banbury mixers and two-roll mills. For preparing moulding and extrusion compounds, the strips are fed into granulators where they are cut into chips of various mesh to suit different applications. For the production of sheet, the mixed and milled compounds are fed to calenders which produce material up to 54in wide and up to 0·030in thick. The calendered sheet in roll form is then either supplied to customers for further processing or is press polished at the works.

There is also now being produced at this works a polyvinyl chloride rigid sheet suitable for construction work in chemical and allied plant.

Transatlantic Telephone Cable

LORD DE LA WARR, the Postmaster-General, announced in the House of Lords on Tuesday last an agreement for the provision of a trans-atlantic telephone cable between Scotland and Newfoundland. The agreement was made between the General Post Office, the American Telephone and Telegraph Company, the Canadian Overseas Telecommunication Corporation, and the Eastern Telephone and Telegraph Company of Canada. Whereas the existing radio-telephone facilities consist of twelve circuits from Great Britain to the U.S.A. and two to Canada, the new cable will provide twenty-nine telephone circuits. The cost of the scheme, about £12,500,000, will be shared between the U.S.A. 50 per cent, the United Kingdom 41 per cent, and Canada 9 per cent. The British contribution will consist of the provision of the cables, which will be made in this country, and the laying operation, which will be performed by the cable ship " Monarch." The cable will be laid between Oban and Newfoundland, a distance of 1950 nautical miles. At Newfoundland it will be linked with another submarine cable to Nova Scotia. Thence the channels will be completed by microwave links to the American and Canadian telephone networks. Repeaters will be installed at intervals of 40 miles. They will be of American design which has been tested in deep water. Laying of the first cable will be started in 1955 and the operation is expected to be completed in 1956.

Alaskan Construction Boom

(By Our American Correspondent)

AT any gathering of American civil engineers and contractors to-day, the topic of conversation is sooner or later likely to be Alaska. For the biggest construction boom which the Territory of Alaska has ever seen is continuing, despite certain reductions in federal expenditure brought about by the new Republican Administration. Of the American civil engineering contractors who are now in their fourth, fifth or sixth season in Alaska, some say, "The honeymoon is over." But, in fact, the bridegroom—the U.S. Army—and the bride—the U.S. Air Force—of this post-war union still occupy the bridal suite! The military defence programme continues to overshadow everything else, and even most public works construction hinges on military schemes. Unfortunately, such a dependence upon Government spending does not make for a healthy economy, and already there are many signs of panic in the midst of plenty. Possibly, the key to the present situation in Alaska is uncertainty. Contractors fear anything which causes even a temporary shutdown of work. The city fathers of the boom towns of Alaska feel that economic uncertainty will accompany an improved world political situation and mean the curtailment of at least some of the defence work. Yet they admit that the country's vast resources form a much sounder basis for her ultimate growth than any amount of temporary Government spending. Alaska is a rugged land where one bad year can ruin a man or his business. The cut-backs in defence spending ordered last spring created enough uncertainty to prevent many contractors from bringing materials and equipment in from the United States for six weeks, and the Alaskan construction season is so short that a considerable part of it was gone before the projects involved were reapproved. Almost everything that is done in Alaska is done against a background of traditional nncertainty. The only certain thing is a fear of what will happen next.

Hundreds of millions of dollars have been put into Alaskan military construction since the last war. Initially, most of the work was concentrated in the Aleutians. The present programme, however, has works scattered thousands of miles apart throughout the Territory. Construction work undertaken on behalf of the U.S. Army Corps of Engineers in Alaska last year amounted to 360 million dollars. These schemes include concrete barracks for 200 and 500 men, power stations, airport control towers, hangars, runways, hospitals, communications networks, warehouses, water-treatment facilities and telephone exchanges. Although most of the big multi-million dollar schemes are of a military nature, the Corps of Engineers is also engaged in a smaller, much-needed programme of civil works. Among its schemes are flood-control works, river, harbour and pier improvements, hydro-electric works and dredging projects. High on the agenda of public works is a major harbour improvement at the town of Anchorage, which will be quite an undertaking, since Anchorage has a 37·7ft maximum tide range, the second highest on the North American Continent. Most construction work on military bases under the supervision of the Corps of Engineers is performed under lump sum contracts, based on competitive bidding, and is awarded after a thirty-day period in which the work is advertised. To give the contractors time to buy materials and equipment, many contracts are awarded in January, February and March, so that the full six-month summer work season can be used to best advantage. Tendering is rapidly becoming more and more competitive. In 1951, an average of four contractors bid on each scheme. By 1952, the number had increased to an average of ten bidders per contract, and by this year the figure was even higher. As might be expected, this development has been accompanied by a return to a more normal working pace on individual schemes. Gone are the universal six-day, fifty-four-hour work weeks, which were even scorned in earlier years, when labourers could easily find seven-day, eighty-four-hour jobs! This year, most contractors have established a nominal six-day, forty-eight-hour work week. In many instances, the progress of construction is relatively slow on account of the prevailing conditions of extreme cold. Temperatures of −20 deg. to −25 deg. Fah. are recorded regularly at Anchorage; −50 deg. Fah. is not exceptional for Fairbanks; −73 deg. Fah. has been recorded at Northway, and −83 deg. Fah. at Snag in the Yukon Territory. According to statistics compiled by the U.S. Air Force, using 55 deg. Fah. as a starting point, a 50 per cent increase in man-hours is required for doing the same amount of work at 0 deg. Fah. At −20 deg. Fah. the increase is 75 per cent. At −40 deg. Fah. it jumps to 100 to 110 per cent, and below that outside work virtually ceases.

From the time of the Klondike and Dawson gold strikes, it has been fashionable for Alaskan prices—including labour's wages—to be out of all proportion to prices anywhere else. Despite this, or probably because of it, few men employed in civil engineering trades leave Alaska with much money. Living costs are high and entertainment costs are higher. A bulldozer operator gets 3.54½ dollars an hour with time-and-a-half for overtime under prevailing union rules. The operator of a 5-cubic-yard shovel gets 4.19½ dollars an hour. Most common labourers receive 3.06 dollars an hour. At a time when labour had to be recruited in the United States all trades were guaranteed 173 hours of work a month. However, now that men flock to Alaska each spring, labour is so plentiful that employment conditions similar to those in the United States prevail. Many men this year and last year left Alaska without finding work. Despite this, Alaska's outlook continues to be good. As far as military construction is concerned, enough money has already been appropriated in Washington to keep the wheels rolling for two more years. In view of President Eisenhower's recent statement that "we have won a skirmish in one battle; we have not won world peace," it is reasonable to conclude that Alaskan military work must continue. The rea Alaskan "old-timers" maintain that the territory's future lies in her forests, mines and fishing industry. They look with misgivings at to-day's boom towns and high prices. But, remembering the traditional course of their own history, Americans like to think that a temporary boom is the inevitable price a country has to pay to bring about an accelerated development of its resources.

American Engineering News

(By Our American Correspondent)

A Strain Gauge Dynamometer for the Calibration of Testing Machines

The National Bureau of Standards has for many years maintained a programme to provide means of verifying the accuracy of tension and compression testing machines ranging in capacity up to 10,000,000 lb. Among the large testing machines in the United States are the 4,000,000 lb machine at the University of California and 5,000,000 lb machines operated by the Department of the Navy in Philadelphia and

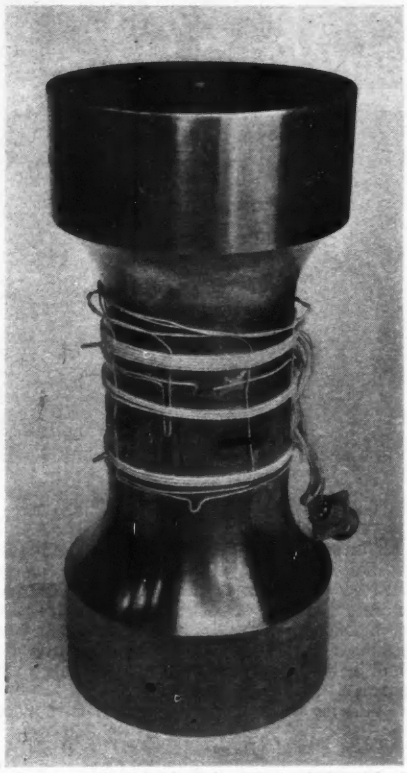


Fig. 2—Column of 3,000,000 lb Dynamometer

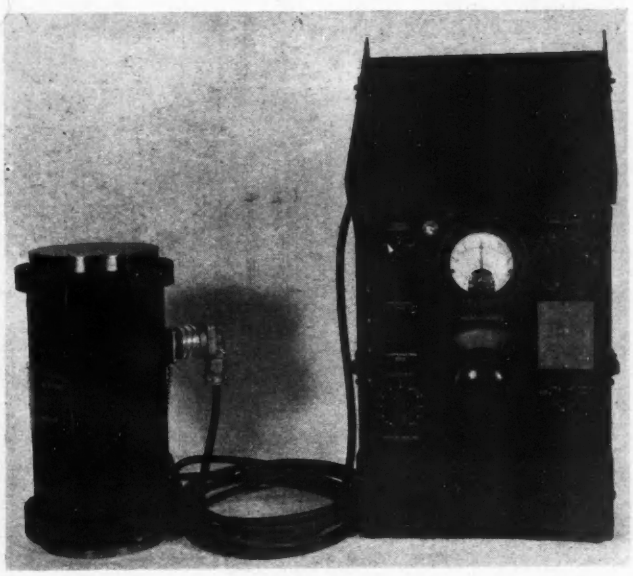


Fig. 1—1,000,000 lb Strain Gauge Dynamometer with Indicating Instrument

by the Bureau of Reclamation at Denver, Colorado. The National Bureau of Standards has long had in its laboratories at Washington, D.C., a machine with a capacity of 10,000,000 lb, which is believed to have the largest capacity of any testing machine in the world. In order that the results obtained in research involving such large testing machines may be considered reliable and comparable with results from other laboratories, it is necessary to control the accuracy of

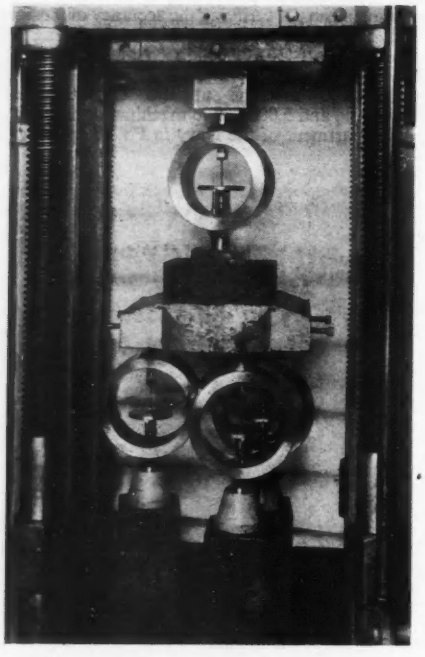


Fig. 3—Calibration of 300,000 lb Proving Ring Against Three 100,000 lb Proving Rings

these machines. It is a simple matter to calibrate smaller machines by the use of proving rings, but the calibration of the larger machines has presented definite obstacles. Proving rings have been made in capacities up to 300,000 lb, and although it is possible to calibrate above this limit by loading several rings simultaneously, the process is costly and difficult.

With the development of a practical bonded wire strain gauge some ten years ago a new method of load calibration became feasible. The gauge consists of a grid of fine wire cemented to the surface of a specimen. As the material of the specimen becomes strained under load the wire is likewise strained, thus changing its electrical resistance. The change of resistance bears a simple relationship to the strain in the specimen and can be measured by suitable instruments. The possibility of utilising a uniformly stressed column having gauges attached in such a way as to respond to the average strain on the column seemed a promising solution to the problem of measuring loads of a million pounds or more. It was known that a device designed in this fashion could work to a much higher load in proportion to its own weight than a proving ring and, since the output of the strain gauges would be correlated directly against load, no assumption need be made as the gauge factor. Accordingly a programme was established at the Engineering Mechanics Laboratory of the National Bureau of Standards to develop load measuring devices utilising strain gauges which would permit the calibration to capacity of the largest testing machines in existence. The objective was to design devices that would achieve the stability and accuracy of the proving ring, i.e. about 0·1 per cent. This programme has now reached the point where eight devices have been completed and calibrated, four with a capacity of 1,000,000 lb each (Fig. 1) and four with a capacity of 3,000,000 lb each (Fig. 2). The latter four offer a total capacity of 12,000,000 lb, which is more than enough to calibrate to capacity the largest testing machine now in operation in America.

The use of wire strain gauges for the measurement of load is by no means new : such devices were being produced commercially for the weighing and balancing of aircraft at the time the Bureau started the development of its compression dynamometer. The new aspects of the devices now developed at the N.B.S. are the application of the method to the measurement of very high loads, the procedure used to calibrate the devices, and the particular detail of design in which a highly stressed column is flared out at the top and bottom to integral ends having bearing surfaces of relatively large area. This design, which is indicated in the photograph (Fig. 2) of the 3,000,000 lb dynamometer column, results in relatively low stresses between the device and the bearing blocks through which they are loaded by the testing machine. Thus accurate and reproducible results are obtained. As shown in the photograph reproduced in Fig. 3, the dynamometers are used in conjunction with an electrical indicating instrument, which is based upon an ordinary commercial strain indicator for strain gauges. The electrical instrument is used to measure the small shift of balance of a bridge circuit composed of elements of resistance wire strain gauges attached to a highly stressed portion of the device. By mounting some of the gauges in such a way as to measure the compressive strains parallel to the load axis of a compression column, and other gauges to measure tension strains caused by the lateral expansion of the same column, a bridge having a maximum output and good temperature compensation can be formed.

The strain gauge dynamometer devices are calibrated by extending the method developed for large proving rings which exceed the capacity of the Bureau's 111,000 lb deadweight testing machine. In calibrating a 300,000 lb ring, the ring is first calibrated as far as possible by dead weights. It is then set up in a testing machine and loaded against three 100,000 lb proving rings, which have been previously calibrated to capacity by dead weights. The load exerted by the machine is transmitted through a 300,000 lb ring and is shared equally by the three 100,000 lb rings, as shown in Fig. 3.

All four rings are read at once and the load is computed from the readings of the three smaller rings. In this way a calibration may be secured to 300,000 lb and the errors of the testing machine do not affect the result. Our final photograph (Fig. 4) indicates how, in a similar manner, a 3,000,000 lb wire strain gauge dynamometer is calibrated in the 10,000,000 lb testing machine of the N.B.S., loading it against three 1,000,000 lb dynamometers, which have themselves been calibrated previously against proving rings. It has been estimated that a testing machine can now be calibrated to 10,000,000 lb by means of the N.B.S. dynamometers in about a quarter of the time which was formerly required to calibrate it to 2,500,000 lb.

Fig. 4—Calibration of 3,000,000 lb Dynamometer Against Three 1,000,000 lb Dynamometers

Laboratory Measurement of Corrosion in Soils

A recent programme of research conducted at the National Bureau of Standards has indicated that reliable data on the corrosion of ferrous metals in soils of various kinds may be obtained in the laboratory in a period of six months, although field tests lasting ten years or more were usually required for the same purpose in the past. In the investigation, which was performed at the corrosion laboratory of the Bureau, corrosion was produced in small laboratory cells by the differential aeration of metal discs in contact with soil within the cells. The results obtained for fifteen different soils in these accelerated tests showed good correlation with the corrosion observed on wrought specimens in long-term exposure tests. This technique should thus provide a valuable basis for predicting the service of iron and steel structures which are exposed to various soils.

It may be recalled that the corrosion of metals in many soils is attributed chiefly to differences in the accessibility of oxygen to the surface. Differences in oxygen concentration create differences in the potential of various areas, resulting in the flow of electric currents through the soil from the oxygen-deficient areas (anodes) to those areas (cathodes) receiving more oxygen. The laboratory corrosion cells used by the N.B.S. made use of this principle. Each cell consisted of a cylindrical cellulose acetate plastic enclosure containing two short-circuited disc-shaped electrodes of the same material, iron or steel. One electrode was solid, the other perforated, and they were separated by a layer of moist soil. The edges and one face of each of the two electrodes were covered with bituminous paint. The layer of moist soil in contact with the coated side of the perforated electrode regulated the diffusion of air to the electrodes. The perforated electrode received a greater supply of oxygen than the solid one, adjacent to which the soil was puddled, and therefore assumed a more positive potential. If the corrosion of ferrous metals in all soils proceeded at a rate that was constant with time, any weight loss measurements made after a short arbitrary period of exposure should indicate relative rates of corrosion, assuming negligible cleaning errors.

Actually, however, it was found that the corrosion in soils may proceed at a rate proportional to time, or may sometimes cease entirely, dependng on the type of soil. It was thus necessary to operate the laboratory corrosion cells for a period sufficiently long to produce effects comparable with those shown by field exposure tests. Accordingly, the corrosion cells were kept on short circuit for six months, and during this time periodic measurements of cell current were taken to determine the progress of corrosion with time. At the end of the period the combined weight losses of the two electrodes were taken as the measure of corrosion. To evaluate the laboratory corrosion cell as a means of predicting corrosion in the field, the samples of soil collected at fifteen exposure sites were used. The results were correlated with weight loss measurements made on short lengths of steel and wrought iron pipe which had been exposed for ten years at the same fifteen sites. An empirical equation relating the laboratory and field data indicated that the laboratory measurements could be used to predict field weight losses with a root-mean-square error of about ± 4 oz per square foot for corrosion rates ranging from 2·5 oz to 30 oz per square foot for the ten-year exposure period. Because the fifteen soils covered the range of corrosiveness of the soils of the United States, this empirical relationship is considered applicable to any American soil.

Because some underground structures, such as piping systems and storage tanks, usually fail as a result of pitting, this factor was also considered. An analysis of the field data showed a good correlation between the weight losses and maximum pit depths on wrought ferrous specimens which had been exposed for ten years at fifty-eight exposure sites. These data were then combined with the first empirical equation to obtain a second equation which can be used to predict, with an average error of $\pm 0{\cdot}018$in, the depth of the deepest pits occurring on wrought iron or steel buried for ten years. For the prediction of weight losses and maximum pit depths on areas greater than the area of the field specimens and for periods of exposure other than ten years, use was made of general equations relating weight losses and maximum pit depths with length of exposure and exposed area. Average values for the constants to be used in these equations have been obtained. It was also found that the corrosion cell could detect significant differences between the corrosion rates of cast iron and steel, which are generally considered to corrode at about the same rate in soils. Thus, the cell might be used to study the effects of variables, including chemical composition, upon the corrosion rates of steels. It is also reasonable to expect that laboratory corrosion cells could be used to predict the corrosion of non-ferrous metals in various kinds of soils. Although measurements with the laboratory cell should not be considered as replacing field exposure tests entirely, it is believed unlikely that materials which corrode at the same rate in the laboratory would corrode at significantly different rates in the field.

PRODUCTIVITY IMPROVEMENT.—In the course of an address on aspects of productivity improvement, Mr. B. H. Dyson, the general works manager of Hoover, Ltd., said that in his company's factories it had been possible to show a progressive increase in productivity of 21·7 per cent per annum. The main headings under which this improvement could be allocated were as follows: product design, 25 per cent; utilisation of material, 15 per cent; capital investment of plant, 20 per cent; improved tooling and methods, 15 per cent; improved floor layout and material handling, 12 per cent, and training of staff—aptitude and effort, 13 per cent. The programme of improvement also resulted in post-war productivity per square foot of floor space being increased by 45 per cent. Moreover, the combined cost of scrap and re-operation was reduced to 1·5 per cent of the direct factory cost.

Problems of Fabrication and Erection in All-Welded Multi-Storey Framed Buildings*

By D. C. C. DIXON, B.A., A.M.I.C.E.

The fabrication and erection of all-welded multi-storey buildings in quantity is a comparatively new development in the United Kingdom. Consequently the design, fabrication and erection techniques are in a state of flux and constantly improving. It is with this fact in mind, the author points out, that this paper must be read.

IT is generally accepted that the saving in weight of steel work of welded fabrication, as against riveted construction, is approximately 15 per cent. The savings arise under the following headings :—

Plate Girders

		Percentage saving
(*i*)	Due to obtaining an increased modulus for a given weight by transferring the areas of the flange angles in riveted work to the flange plates in welded work, also due to avoiding drilling and the consequent use of the gross area instead of the net area in the tension flanges. The allowance for flange curtailment is the same as in riveted work	12
(*ii*)	Due to the rational design of stiffeners for welding, i.e. the whole stiffener is outstanding and no leg is necessary for fixing	4
	Total	16

Box Girders and Box Columns

(*i*)	Due to obtaining the same inertia for less weight, and better radius of gyration due to transferring the corner angles in riveted construction to the plate areas in welded construction	2½
(*ii*)	Due to the rational design of stiffeners	3½
(*iii*)	Due to the elimination of gussets, cover plates and rivet heads	9
	Total	15

This saving is to some extent offset by an increase in fabrication cost, but there is, nevertheless, an appreciable saving in the total cost.

Table I shows the total productive man hours of labour per ton to be 56·04 for a welded structure as against 54·15 for one riveted at a particular works. Both jobs quoted suffered from much the same delays due to irregular deliveries of steel. The figure for welding is based on the first two years' work on structures of this type at that works. With the experience already gained the present figure at that works is between 54 and 55. In addition, there is an additional cost of 20 to 30 shillings per ton (at present prices) due to the cost of electrodes. This price is being reduced constantly as the new techniques improve, and the time when the rate per ton for welded structures becomes less than that for riveted structures is well in view.

Because of the many changes that are taking place in techniques, it is intensely important that collaboration must take place between designer, fabricator and erector, so that each may be constantly aware of the experience of the other and profit by it. A good illustration of design to assist fabrication occurs in the case of crane gantries where they are of built-up " H " section. Many have the surge girder in the form of a plate welded to one side of one flange. This inevitably causes bowing, in the plan view of the girder, which must be removed by one method or another. It is possible, however, to design the surge girder in the form of brackets off the web of the plate girder which obviates distortion during fabrication. Many similar examples could be quoted. No riveting must be allowed in a structure of this type unless due consideration shows it to be of great advantage.

* Abstracts. Paper presented at the Conference on Welded Structures, Institution of Civil Engineers, November 23, 1953.

WORKSHOPS METHODS

The operations required in the fabrication of multi-storey buildings can be divided into two categories; firstly those which are carried out in the assembly and welding bays; secondly, those that are not. Since for a given throughput of this kind of steelwork the assembly and welding bays are the largest in area and crane capacity, it is clear that a greater capital expenditure is required in these bays than any other. Table II shows that the man hours per ton required for the operations of plating and welding and their associated labour to be greater than those required in any other bay. It is therefore clear that the greatest benefit to productivity will be obtained by improvements in methods in these bays.

TABLE II.—*Analysis of Fabrications for a Generating Station Housing 4–60MW Turbo-Generators*

	Pieces, No.	Weight, tons
Box sections :		
Depth 2ft 6in to 6ft ; width 2ft to 2ft 9in ; length 37ft to 86ft ; flange thickness ¾in to 1¼in ; individual weights from 5 to 22 tons	116	1793
Depth 2ft 6in or less ; width 2ft or less	36	108
Built-up " H " sections :		
Web depth 4ft or less ; flange thickness 1in or less ; individual weights from 1½ tons to 3½ tons	488	947
Web depth 4ft or less ; flange thickness 1¼in to 1¾in ; individual weights from 3½ tons to 5 tons	80	298
Web depth 5ft ; flange thickness over 1¼in	18	135
Web depth 8ft and 10ft ; individual weights from 5 tons to 16 tons	36	342
Rolled sections :		
With drilling and welding of cleats only	—	1953
Weldments :		
Widely varying sizes, shapes and weights. (A large proportion occurs in the bunkers)	—	1001
		6577

Note.—Another station for which an analysis has been made has larger bays but shows approximately the same divisions of sections. These, however, include a proportion of pieces of greater size, e.g., box sections 10ft by 3ft by 53ft weighing 33 tons each, box sections 6ft by 2ft by 95ft weighing 32 tons each. Flanges on box sections up to 2½in thick.

Table II shows an analysis of the weldments required for a generating station. In view of the spans between columns and the loading of such a building, it is likely that this analysis shows as great a range of size of weldment as is likely to be encountered. A method of fabricating the generating station shown in the analysis in a cheap and efficient manner is therefore likely to be applicable to the majority of other multi-storey buildings.

In the fabricating shops from which all the figures given in the appendices are taken, work on buildings of this kind has been proceeding for three years and a great deal of development in method has been attempted during this period. Reports have been submitted by independent observers, one eighteen months ago, one six months ago, on the lines to which future development might be most profitably directed. The main conclusions of each have been identical. They recommend that the greatest benefit would be obtained from, firstly, improved handling facilities; secondly, better organisation.

Bunkers are not common to the majority of multi-storey buildings, and their fabrication will, therefore, not be considered. It will be seen from Table II that this leaves four main classes of weldment, i.e. : (*i*) box sections ; (*ii*) built-up " H " sections ; (*iii*) outsize members of classes (*i*) and (*ii*) ; (*iv*) rolled sections, with drilling and welding of cleats only.

Classes (*i*) and (*ii*) have two major factors in common : firstly, that their minor dimensions can be enclosed by a rectangle 6ft by 2ft 9in ;

TABLE I.—*Fabrication, Man Hours Per Ton*

Period	Weight, tons	Type of fabrication	Labour	Crop saw roll	Template	Shear	Plane	Mark and drill	Smith	Gas-cut	Plater	Platers' helpers	Rivet and chip	Weld	Paint	Fitting and machine	Joiners	Overall
December, 1949 to August, 1952	2872	Riveted power station	13·75	3·33	4·43	0·24	1·16	9·22	0·32	0·55	5·22	7·83	5·22	1·26	0·25	1·37	—	54·15
February, 1952 to February, 1953	4000	Welded power station	14·50	3·35	3·49	0·34	1·88	4·78	0·80	0·66	6·68	7·93	0·67	10·00	0·10	0·83	0·03	56·04

secondly, that the necessary manipulation need be about the major axis only. This indicates the possibility of manipulators common to both classes of section. The numbers of each suggest that line production methods may be employed to a considerable extent. Members of classes (*iii*) have such variations in dimensions and weights that individual methods of handling must to a great extent be employed.

Rolled sections of class (*iv*) will invariably weigh less than 2 tons each and a great proportion less than 1 ton. It is, therefore, not economical that they should be handled in the main bays served by cranes of 10, 20 or more tons capacity. Nor with the small number of operations and the large number of lifts required for a given tonnage, is the tempo of these bays suitable. These factors indicate that smaller shops, with handling equipment smaller by capacity but greater in number, are suitable for this type of work.

An automatic welding machine can lay the heavier welds on these weldments much faster than a hand welder. The use of these automatic welding machines, therefore, appears advisable and must be considered.

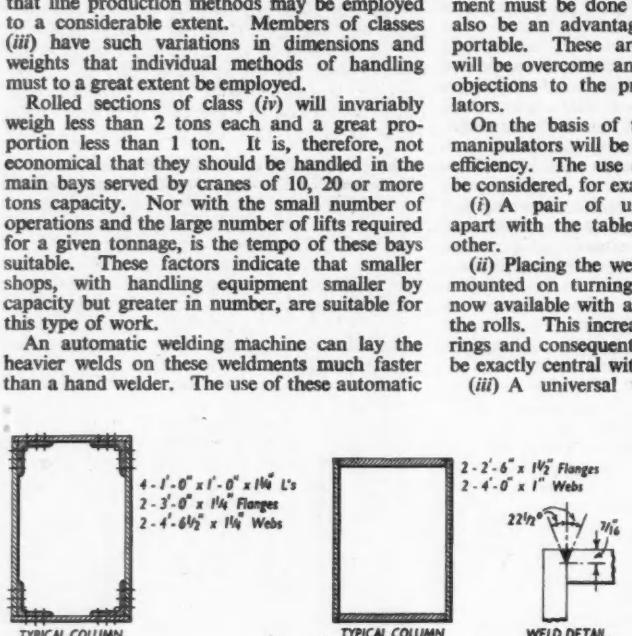

4 - 1'-0" x 1'-0" x 1¼" L's
2 - 3'-0" x 1¼" Flanges
2 - 4'-6½" x 1¼" Webs
TYPICAL COLUMN SECTION.
Web 3'-0" x 3/8" to 10'-0" x 3/4"
Flanges (1 to 3) 1'-0" x ½" up to 2'-4" x 3/8" Top and Bottom
Angles (4) 4" x 4" x 3/8" up to 8" x 8" x 1"
PLATE GIRDERS.
(a)
2 - 2'-6" x 1½" Flanges
2 - 4'-0" x 1" Webs
22½°
7/16"
TYPICAL COLUMN SECTION.
WELD DETAIL (Submerged Arc)
Web 2'-3" x 3/8" up to 10'-0" x 1¼"
Flange (1) 10" x 3/8" up to 2'-0" x 1¾" Top and Bottom
PLATE GIRDERS.
(b)

Fig. 1—(*a*) *Riveted Power Station* (*b*) *Welded Power Station*

Fig. 1 shows the general arrangement of some box sections and various details of the main longitudinal welds. Manipulators were designed to accommodate both box and " H " sections and the design was based on two main assumptions.

(*i*) That when the two welds on one side of the box were laid the box would bow; but that when the two welds on the other side were laid they would correct this bow. The manipulators were therefore designed to offer no restriction to bowing.

(*ii*) That although each pair of welds would be laid by two automatic welding machines running from one end of the box to the other, with the arcs opposite to each other across the box, some twist or lateral distortion would occur. The manipulators were, therefore, designed to restrain any such twist.

Assumption (*i*) was correct. Boxes have been welded of the full range shown in the analysis of the generating station. In the case of 48ft box sections a bow of as much as 1¼in has been observed after the first pair of welds were laid. However, after welding has been completed and the metal has cooled, no box has been found to have a greater bow than ¼in.

Assumption (*ii*) was not correct. Only where it has been necessary to burn out a faulty weld and then re-lay it, has any twist occurred, and this twist has been far less than was anticipated. Welds can be and are laid on the four seams in succession (but all on the same day before cooling is complete) and no twist occurs.

To achieve strength against twist, tapered turned-bolt connections between the segments were employed. To remove a set of three segments (i.e. one in each ring) it is necessary to remove thirty bolts. The time for this has made the manipulator of doubtful use except where the weldments are most awkward to handle, or must be turned over many times. Another disadvantage of this manipulator, which is the largest of three types, is the height of the work, which means that work on the weldment must be done from platforms. It would also be an advantage if this manipulator was portable. These are, however, details which will be overcome and cannot be considered as objections to the principles of using manipulators.

On the basis of the experience gained, the manipulators will be redesigned to be of greater efficiency. The use of various other kinds will be considered, for example :—

(*i*) A pair of universal manipulators set apart with the tables vertical and facing each other.

(*ii*) Placing the weldments in rings which are mounted on turning rolls; turning rolls are now available with an endless belt passing over the rolls. This increases the bearing area of the rings and consequently the weldments need not be exactly central within the rings.

(*iii*) A universal manipulator has recently come on the market working on the principle of holding the weldments in such a fashion that it is always perfectly balanced, no matter in what manner it is rotated. Its ease and speed of use suggest it may be of great value. Models at present available can handle only pieces of limited weight and dimensions, but there does not appear to be any insuperable difficulty to the development of much larger manipulators of this kind.

The particular type of manipulator used must eventually depend on : (*a*) the type and range of work to be fabricated; (*b*) the amount of work to be fabricated, and (*c*) the equipment, space and machinery already available.

After welding the main seams the following operations must be carried out on each box section :—

(*i*) On each of three faces mark the centre line and both ends for facing.

(*ii*) On all four sides mark the cleat positions, place the cleats and tack weld them.

(*iii*) Make a rough check of the cleat positions by a chargehand plater or a template-maker against any gross errors.

(*iv*) Fully weld the cleats on all four sides.

(*v*) Make a final accurate check of all marking and of the cleat positions.

These operations necessitate the box section being turned over a number of times. Where the box section is in a mechanically operated manipulator the number is largely immaterial. Where it is not in a manipulator the number of turns becomes a ruling factor in the throughput of boxes. These operations require men of several trades. Each must perform several operations which cannot be carried out concurrently. For the box sections to require the minimum of turns (which is eleven) the number of times men of each trade are required is increased. This requires overcoming great organisational problems if delays are to be avoided.

Since it has been found in practice that, including all delays, all but the outsize boxes can be assembled complete with all internal diaphragms and stiffeners in a day and a half, and the welding of the main seams in another day, it can be seen that the efficiency with which these latter operations (i.e. (*i*) to (*v*) mentioned above) are carried out, is a major factor in speed of production. This efficiency depends more upon organisation than upon technical difficulties.

The considerable time required by skilled men to mark the column and to place all cleats and subsequently to check all dimensions of the box sections, suggests an investigation for methods that are both quicker and more economic in man hours. The use of mechanical or optical methods have, however, certain difficulties to overcome.

(*i*) The magnitude of linear dimensions.

(*ii*) (*a*) When the box sections are in the manipulators the difficulty due to the projection of the latter.

(*b*) When not in manipulators the difficulty of ensuring the level of the centre line throughout the length of the box section.

(*iii*) The liability to damage of such equipment.

Since it is generally desirable to drill such holes as may be required after welding because of the difficulty of estimating accurately any shrinkage that may occur, the handling and positioning of plates is made more difficult since, for example, shackles cannot be fixed nor can drifts be employed. There are two methods of surmounting this problem which are worthy of mention.

(*i*) Temporary studs can be welded using a stud welder which is subsequently chipped off and ground flat. The use of such studs is also valuable for light connections such as those required for wall ties or for hand-railing.

(*ii*) Permanent magnets are available in several sizes and shapes which have great power in relation to their weight. Examples of their use are in the setting of stiffeners on the webs of " H "-section girders. The 488 girders in the generating station in Table II have of the order of 10,000 stiffeners. Thus, though the saving in time and money on each may be small, the combined effect is considerable. Also two can be used in conjunction, with a suitable light framework, for positioning diaphragms on the flange plates of box girders. It is considered that further applications of magnets might usefully be developed.

The great speed at which welds can be laid using automatic machines when compared with the lessers speeds at which welds are laid by hand, indicates the value of machine welding. The positioning of the work in the downhand position, the better fit-up required and the time taken in getting the machine ready to do the work, may, however, largely nullify this advantage unless much care is taken. The greater the efficiency achieved in this preparatory work, the shorter the runs which can be economically laid by machine.

There are two methods, in general, of using automatic welding machines on structural steelwork.

(*i*) Mounting the machine on a gantry or some kind of travelling bracket and placing the work in a suitable position beneath it.

(*ii*) Running the machine on the job to be welded.

The third possible method of passing the work under a stationary machine does not appear applicable in the structural industry except in specialised work, e.g., pipe lines.

The first method requires a considerable capital expenditure, possibly a fair amount of floor space and therefore a large run-of-work for it.

The second method is more flexible, but the setting-up of each job will take longer.

In both cases one of the problems to be overcome will be the handling of the electrical cables leading to the machine.

In the extension of the economic use of automatic welding machines lies one of the major ways in which more efficient fabrication may be achieved. This extension of use is inevitably connected with the improvement of handling facilities.

In fabricating " H "-section girders, it must be decided whether the longitudinal fillet welds shall be made by machine or hand. If the former, then the stiffeners must be placed subsequently to the flanges. In general, where a considerable number of girders is to be fabricated, thus justifying a fairly elaborate set-up, it is considered that a ¼in fillet constitutes the border-line case.

The distortion of the flanges during welding is a problem. Either the flanges must be preset or they must be restrained during welding and cooling. If the former, it can be done in a hydraulic press, or there is an alternative that it

might be done using a special pair of rolls. The amount of pre-set depends mainly on the width and thickness of the flanges and the size of fillet to be laid, and must be determined partly by experience. The conditions, e.g., temperature, under which the welding is carried out must be known, as these are known to make an appreciable difference. If the distortion is to be restrained, this is usually done using strongbacks. Where the flange plates are approximately $\frac{3}{4}$in or less, a preset can be obtained using opposing wedges under the toes of the strongbacks. However, unless the strongbacks are used at very frequent intervals, there is likely to be some wave in the flanges. The harm done by this wave is a matter of opinion. Where the flanges are over 10in in width the strongbacks are likely to be of inconvenient weight for man-handling, and it is possible that aluminium alloy strongbacks might be practicable. In any case, strongbacks cannot be efficiently used where the flanges are of great thickness.

Despite careful rolling, plates, especially when large, are not always so flat that when plated the fit-up is good enough for welding. To achieve this fit-up generally requires considerable force. It is suggested that a method of overcoming this difficulty is by the use of toggle clamps. These can easily be designed to give a great mechanical advantage over a very short distance, which is the precise requirement usually required for improving the fit-up of plates. These means are not practicable where the plates are of great thickness.

The generating station, the members of which are analysed in Table II, required in the columns alone, 73,000ft of plate of various thicknesses to be planed and bevelled. If done on a plate-edge planer this requires the time of a large machine (the plate lengths reach over 50ft in some cases) for a long period. The use of flame planers is suggested, the capital cost of which is less than that required for an edge planer of equivalent capacity. The cutting flames can be arranged on gantries so that both sides and both ends of a plate can be cut and bevelled at the same time without moving the plate. This may result in a considerable saving in time and space, and certainly requires fewer lifts by cranes.

Particular reference has been made in preceding paragraphs, to the need for good organisation. There are several characteristics of welded structures that make this of particular importance.

(*i*) Various trades are required successively, and in some cases more than once, for relatively short operations on the same box section. This occurs to some extent on various other sections.

(*ii*) Each individual member, whether major box section or rolled beam, has invariably a number of small cleats welded to it. These cleats are of a large variety and section. It is therefore a problem to ensure that all parts of a member reach the assembly bay at the correct moment.

(*iii*) Where production is proceeding smoothly, it should not be necessary for box sections (where not outsize) to be in the welding assembly bays more than seven working days or "H" sections more than three days. The need for good progressing of sections and plates is therefore emphasised.

The welding of structural members raises some labour problems which must be considered. The welders are generally employed on either tack welding or production welding. The former is on time, bonus or equivalent rates, the latter usually on piece rates. The piecework is preferred by the welder as it generally enables him to earn better wages. The extension of use of automatic machines will therefore be unpopular unless it is accompanied by such alterations in rates as will make up for this. A stud welder where it is used to provide temporary studs for ease of assembly, would appear to be a platers tool; however, where the studs are permanent fixtures it would seem to be a welder's tool. Some arrangement must be made by which this does not occasion wasted man-hours. In the assembly of most structural members, a team of three men is employed, i.e. plater, plater's helper and welder. In many cases the work could be equally efficiently carried out by a plater who is permitted to tack weld, and his helper.

It is suggested that the answer to all these problems—and there are several similar—lies in a realisation of the benefits of higher productivity and greater efficiency, collaboration with managements, especially in the trial and use of new methods and machines, and vigilant but co-operative trades unions.

Quality

The quality of welded structural steelwork depends not only on the methods of fabrication employed, the operators, and the efficiency and rigidity of inspection, but also on the design.

To take a few examples only. The design will determine to a more or less extent, the intensity of locked-in stresses, the amount of welding that can be done in the downhand position, and the occurrence of notches. Although structures such as those considered are rarely subject to fatigue loading, these points are of some importance.

It is rarely economic to restrain distortion during welding of members, it is usually better to perform the welding in such a manner that the member may move freely during welding, but so that when cooled it will take up its correct shape. This method (since stress relieving can rarely be justified in structural work) will usually leave lesser stress concentrations in the final article than if restraints were applied during welding.

It has been shown that where fatigue strength is the criterion, welds laid in the downhand position are considerably better than those laid in the horizontal or vertical positions. The former welds are also quicker to lay.

It can fairly be said that in general the best fabrication techniques are also the best where quality is concerned.

Only visual inspection of welds is usually employed on structural steelwork. Whilst many faults can be seen or inferred from the final weld, there are some that cannot. It is, therefore, necessary to ensure that inspection operates also whilst the welds are being laid.

Faults in plates and sections as received from the mills, such as discontinuities, laminations and lack of homogeneity may not become evident at all or until a considerable amount of work has been done upon them. In the former case the quality of the completed work suffers; in the latter considerable cost and delay may be incurred. It is a problem to know what degree of inspection should be carried out on steel as it enters the works. The cost of X-ray inspection is prohibitive, magnetic inspection cannot reach deep enough into the metal, and ultrasonic inspection finds it difficult to differentiate sufficiently between serious and not so serious faults.

Errors are costly to rectify, particularly when they are found at site. The works at which the figures for man-hours were taken, employ a template-maker for final dimensional inspection. This explains why this figure is so high. It is considered that this expenditure has proved well worth-while.

Erection

The erection of welded multi-storey framed buildings is easier, quicker and cheaper than with similar structures which are riveted. The following comparative figures illustrate this statement. One bay of a riveted power station, weight 1500 tons, took thirteen weeks erection time or 115 tons per week. One bay of a welded power station, weight 700 tons, took five-and-a-half weeks' erection time or 127 tons per week. The figures for tons per man per month (including all men except the general foreman) are more impressive. The riveted station worked out at 7·1 tons per man per month. The welded station at 12·5 tons per man per month. The conditions necessary to achieve these results or better, are first, a good practical design of detail, particularly in the connections; secondly, accurate fabrication; thirdly, few mistakes.

Alterations at site are more difficult with welded work, due to welded connections having to be chipped off. However, additional connections are much easier to make than with riveted work.

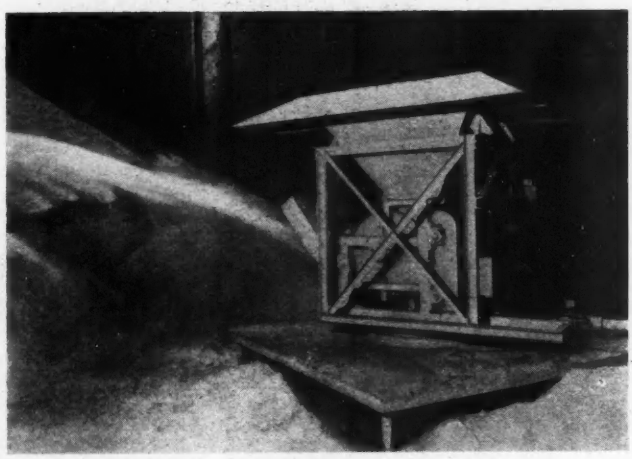
The reasons for these results are various. The connections are simpler and there is an absence of cover plates. Very little scaffolding is required in landing pieces and making joints on account of their design, e.g., internal flanged connections. A good example of these first two points is found in the column joints. Where riveted they require approximately 12 man-hours to scaffold, 24 man-hours in fixing cover plates, 18 man-hours landing the piece and bolting up the cover plates. Where welded they only require approximately 12 man-hours to land the piece and complete the joint.

Technically there is no objection to welding at site. Experience in the erection of buildings where most main connections are made with turned bolts and few with rivets has shown this type of erection to be so quick and easy that it is extremely doubtful if site welding could provide any improvement. Supervision also is extremely difficult.

From the foregoing discussion it can be seen that the main emphasis falls on two points. Because the members of the present-day multi-storey building can be divided into a few classifications, possibilities of line production methods are indicated. The main field for development here is in the handling equipment (mainly manipulators). The right type will permit the extension of use of automatic welding equipment. This handling equipment is likely to require considerable capital expense. It is, therefore, an important matter that designers and fabricators should collaborate so that the equipment chosen is not only the best for existing designs, but shall be capable of modification to suit all developments in designs that can be foreseen.

Sugar Thrower

Many different aspects of cargo handling have been the subject of investigation by the various panels of the International Cargo Handling Co-ordination Association in an effort to improve present practice and to expedite the turn-round of ships. Among the problems which have been studied has been the handling of sugar cargoes when they are shipped in bulk, which is the present-day tendency, due to the high cost of transport in bags. Experiments were carried out last year in the handling of such cargoes, both in Liverpool and in London, and a description of an overhead loader for the mechanical trimming of bulk



"Meteor" Sugar Thrower

cargo appeared in our issue of November 14, 1952. As a result of the experiments further developments have taken place under the auspices of the International Cargo Handling Co-ordination Association and Crone and Taylor, Sutton Oak, St. Helens, has developed, in collaboration with Mr. D. R. Smith of the Association, a sugar thrower for a leading shipowner.

This throwing machine, known as the "Meteor" thrower, has been specially designed for stowing granular cargo and is powered by a 10 h.p. electric motor. Our illustration of the machine on test in a warehouse shows that the thrower is surmounted by a supply hopper, which is 4ft 6in square, and a canopy some 7ft square, and is carried in a steel framework. This is mounted on a turntable fitted to a base measuring about 8ft square and equipped with four locating spuds. A detachable tubular lever is fitted to assist in rotating the machine, which has a height of 7ft 2½in from the underside of the base to the top of the canopy.

For carrying out the sugar stowing operations the following procedure is followed. The sugar is loaded by grab into the main hold of the ship to form an initial dump load rising to a level within 8ft to 10ft of the lowest deck, at which stage the thrower is lowered on to the flattened crown of the dump load. Meanwhile, the main feed hopper, which is 9ft square, is positioned in the hatch opening at about one 'tween deck height higher than the thrower and vertically above it. The sugar is fed by grab into the upper hopper and from it is directed to the thrower which can deal with about 90 tons per hour and can throw the sugar a distance of between 50ft to 60ft, so that the cargo can be loaded throughout the hold. When the main hold is completed the process is repeated and the thrower is raised to successive 'tween deck levels to finish the loading operation.

Portable Air Compressor

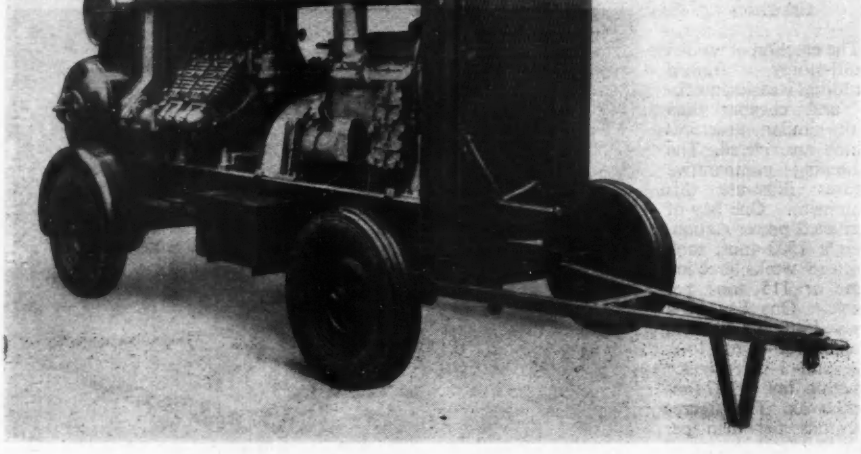
A RECENT addition to the portable air compressors made by the Lead Wool Company, Ltd., of Snodland, Kent, is the machine illustrated below. It has a piston displacement of 250 cubic feet of air per minute. This machine is mounted on a rigid welded steel channel chassis fitted with pneumatic-tyred road wheels. It is powered by a four-cylinder, 60 h.p., 1375 r.p.m., Meadows engine, which drives the compressor through a single-plate clutch.

The compressor is of the firm's four-cylinder, vee type with two high-pressure and two low-pressure cylinders arranged in blocks together. The high-pressure cylinders have a bore of 4¼in and the low-pressure cylinders a bore of 6 11/16in, the stroke being 4 7/16in. When driven at 1375 r.p.m. the compressor delivers about 210 cubic feet of free air per minute at 100 lb per square inch.

The cylinder blocks of high-grade nickel cast iron are fitted with separate heads, the high-pressure piston being of cast iron and the low-pressure piston of aluminium alloy. A cast Meehanite crankshaft, which runs in gunmetal backed white metal bearings, is dynamically balanced to reduce vibration to a minimum. A submerged oil pump gear driven from the crankshaft delivers oil to the main and big end bearings. Fully automatic steel disc multi-port valves are fitted and are readily accessible on removal of the valve covers on the cylinder heads.

An intercooler mounted behind the compressor has header tanks of fabricated steel construction, with sectionalised tubes so that each element can be easily removed for cleaning purposes. The radiator block is divided into two sections, between which is fitted a cooler for the engine lubricating oil.

The machine has been designed to give the greatest possible degree of accessibility to all working parts to facilitate inspection and maintenance, and in full working order it weighs some 2 tons 16 cwt.



Portable Air Compressor

Turbine Gear Wheel Shaving Machine

220in Gear Shaving Machine

A TURBINE gear shaving machine which can accommodate turbine wheels 220in diameter and weighing up to 100 tons, has been designed and built by David Brown Machine Tools, Ltd., Manchester, and installed at the works of John Brown and Co., Ltd. It is being used in conjunction with a 49in pinion shaving machine and is designed for what is termed "crowd" shaving, a super finishing process for removing the minute undulations inherent in gears cut by the hobbing process. The new machine weighs 130 tons and is 33ft long by 35ft wide with an overall height of 16ft. It is fitted with a pinion mounting bracket at the rear so that if required it can be used as a testing bed without necessity for removing the large wheel from the machine.

The general arrangement of the machine can be seen from the photograph taken of it undergoing tests at the maker's works, which we reproduce on this page. Its main bed comprises two heavily ribbed castings tenoned and bolted together, and on this bed are mounted a shaving head slide bed, the wheel pedestals and the bracket for the pinion pedestals. During the shaving operation the wheel is driven by a 30 h.p., 1000 r.p.m. motor through pick-off gears by which the work speed can be varied from 7 to 30 r.p.m.

The shaving head slide can be adjusted on the main bed to enable the accommodation of gears of any centre distance from 48in up to the maximum diameter of 220in. The cutter has a maximum traverse of 100in and wheels with face widths up to 100in can be machined. Cutters of 2½in bore are used with diameters ranging from 8in to 14in. An independent 6 h.p. motor is used to drive the saddle feed motion and through pick-off gears saddle cross-feeds from 0·03in and 0·07in per minute are available. The operating drive is applied to the wheel being shaved and there is no rotational drive to the cutter which is rotated solely by its contact with the main wheel.

To facilitate the setting of the machine the saddle is provided with a quick power motion of 36in per minute and the shaving head with a quick traverse speed of 12½in per minute.

The cutter head is fitted with a brake on each side of the cutter for selective shaving, which may be necessary to obtain about 95 per cent bearing across the face width of a gear, allowing for slight relief at the ends. Push-button controls for all the machine motions are conveniently grouped on the side of the saddle, where there is also a handwheel for fine feeding the shaving head.

Industrial and Labour Notes

Changes in Wage Rates

The changes in wage rates, which were reported to the Ministry of Labour as coming into operation in the United Kingdom during October, resulted in an aggregate increase of approximately £284,000 in the weekly full-time wages of 1,309,000 workpeople. There was also a decrease aggregating about £6100 in the weekly full-time wages of 189,000 workpeople.

The decreases, which resulted from sliding scale arrangements based on the index of retail prices, mainly affected workers in the iron and steel industry, in the hosiery dyeing trade in the Midlands, and ironstone and limestone mining workers in some districts. Those receiving wage increases in October included building operatives in certain districts of England and Wales, dock workers, and certain grades of non-skilled workers in Government industrial establishments.

At the end of October the index of rates of wages (June 30, 1947=100) remained unchanged at 137 for all workers. It had risen by one point in September. The Ministry of Labour has stated that, in the first ten months of this year, changes in wage rates have resulted in an aggregate increase of £2,153,600 in the weekly full-time wages of 7,900,000 workpeople. In the corresponding period of 1952 there was a net increase of £3,322,000 in the weekly full-time wages of 8,553,000 workpeople.

Trade Disputes

The Ministry of Labour has stated that altogether there were in progress in the United Kingdom at some time during October 212 stoppages of work through industrial disputes. The total included fifteen stoppages which had started in September. In these 212 stoppages, 116,000 working days were lost in October by the 39,900 workpeople who were involved in them. Eight of the stoppages occurred in the engineering industries. There were 1500 workpeople involved in them, the aggregate number of working days lost being 10,000. In the first ten months of this year, there were 1416 stoppages of work through disputes reported to the Ministry of Labour. The number of workers involved in them was 235,500 and 955,000 working days were lost. In the comparable period of last year there were 1483 stoppages reported, involving 317,000 workers and resulting in a loss of 1,535,000 working days.

Coal Production

The Ministry of Fuel and Power has stated that coal output last week totalled 4,724,700 tons which was higher than in the preceding week and in the comparable week of 1952. In the first forty-seven weeks of this year, coal production amounted to 202,253,800 tons, compared with 204,509,600 tons in the corresponding weeks of last year. Coal imports this year, so far, have amounted to 449,500 tons. The number of workers on colliery books on November 21st was 709,200, of whom 299,000 were working at the coal face. On the same date distributed coal stocks totalled 19,021,000 tons, compared with 19,227,000 tons a year earlier.

Exports

Some observations on the United Kingdom's export trade were made by Mr. D. Heathcoat Amory, Minister of State, in a speech, on Thursday of last week, to the Engineering Industries Association at Newcastle upon Tyne. He said that the present position was "far more precarious than we would like to see it," and that although we were to-day once more paying our way we were only just doing so. The terms of trade had been working in this country's favour lately, but they might not go on doing so and, Mr. Heathcoat Amory commented, if the level of business activity in the U.S.A. were to drop off things would get much more difficult. International competition, which was getting stronger every day, might well become a good deal more intense.

Mr. Heathcoat Amory went on to say that, this year, exports had been recovering slowly from last year's setback, but the pace was not fast enough. Total production in this country was going up once again, but the share of that extra production going for exports was too small. The total of the country's engineering exports, for instance, was down compared with the same period last year. Productivity, too, he added, was again turning upwards, but satisfaction at that good news must be tempered by the knowledge that productivity on the part of our most vigorous international competitors seemed to be rising a good deal faster still. World trade, Mr. Heathcoat Amory continued, was still increasing, but not this country's share of it. Our share must be increased, and that meant going out and hunting for business in every single market.

Later in his speech, Mr. Heathcoat Amory emphasised the importance of efficient production methods. In some cases, he said, we were already losing important business through prices being too high. It would be a tragedy if through any further rise in costs at a time when our competitors were lowering their prices, we were to price ourselves out of the market and lose all.

Industrial Production

The index number of industrial production (1948=100), which is prepared every month by the Treasury's statistical office, has been estimated provisionally at 125 for all industries in September, compared with a revised figure of 106 for all industries in August. In the corresponding months of last year, the figures were 116 for September and 98 for August. The figures for August, of course, were affected in both years by annual holidays. Taking the various industry groups separately, the Treasury says that the index for the manufacturing industries in September this year was 128, or twelve points above the figure recorded for September, 1952. On the other hand, mining and quarrying, at 112, was two points below the September, 1952, number. On the basis of information which has so far been received, the index number for all industries in October is expected to be 127 or 128.

Mines and Quarries Bill

The Mines and Quarries Bill was introduced in the House of Commons last week by the Minister of Fuel and Power, Mr. Geoffrey Lloyd. It is a measure which consolidates and revises the existing law relating to safety and health in mines and quarries. The present legislation is provided by the Coal Mines Act, 1911, which covers also ironstone, shale and fireclay mines, the Metalliferous Mines Regulation Acts, 1872 and 1875, which covers all other mines, and the Quarries Act, 1894. The new Bill makes provisions for management and control in mines and quarries; safety, health and welfare, the notification and investigation of accidents and diseases, and the employment of women and young persons. It is stated that as this Bill is essentially a revision of the existing Acts, it will not result in any forseeable increase in expenditure. All the expenses and receipts provided for in the Bill exist at present.

Copper Supplies

The Minister of State, Board of Trade, was asked in Parliament on Monday last whether he was aware that there was at present a shortage of copper and what undertakings he obtained from the producers for a regular supply before removing the controls from the trade.

In reply, the Minister, Mr. Heathcoat Amory, said that there was no serious shortage of copper at present, and that such local shortages as did exist while the market was becoming adjusted were met by the Government broker for the time being. The producers were not asked to give formal undertakings about supply to this country after the market opened, and with the return of copper to private trading it was for the consumers to arrange for their own supplies. The Government, nevertheless, did obtain from the Commonwealth producers informal assurances of their continuing attention to United Kingdom needs.

Statistics About Industry

The Trades Union Congress has made a statement to the committee set up by the Government to consider the future of the censuses of production and distribution. This statement urges that there should continue to be a yearly census of production and that there should be a full census of distribution every five years, with the next one as soon as possible. Both censuses, the T.U.C. says, provide valuable sources of information about the state of Britain's economic life.

The T.U.C. has also said that, compared with the amount of statistical information collected and published about the economy of the U.S.A., British industry is not overburdened by the amount of information it is asked to supply. It is suggested that, to help industry, the Board of Trade should draw up and publish a ten-year programme outlining the information sought at each of the annual censuses of production and at the censuses of distribution during that period. About the census of production, the T.U.C. thinks that at the first opportunity there should be another inquiry like that of 1939 surveying the financial connections between firms in different trades and giving details of how far production within each trade was concentrated in the hands of a few firms. The T.U.C. believes, too, that it would be helpful if there was more detailed information about productivity and capital investment and if there was a more complete breakdown of the difference between the cost of materials and the value of total output. Finally, the T.U.C. says that the "data in the census reports is essential to the trade union movement in framing its policies to promote full employment, economic stability and rising living standards, and for the organisation and control of industry."

Membership of Trade Unions

The Ministry of Labour has compiled some statistics of trade union membership from data supplied by the Chief Registrar of Friendly Societies and by the Registrar of Friendly Societies for Northern Ireland. The figures relate to all organisations of employees—including those of salaried and professional workers as well as those of manual workers—which are known to include among their functions that of negotiating with employers over conditions of employment.

These statistics show that, at the end of last year, the aggregate membership of trade unions in the United Kingdom was about 9,524,000, the highest figure yet recorded. This figure included the membership of all trade unions known to the Ministry of Labour to have their head offices situated in the United Kingdom. On this basis, the total number of trade unions known to have been in existence at the end of last year was 690, including twenty-five with their headquarters in Northern Ireland. The total was nineteen less than at the end of 1951, the reduction having been brought about by twenty-seven small unions being absorbed by larger unions or otherwise ceasing to function, and by the formation of eight new unions. Although the tendency towards amalgamation has resulted in a progressive fall in the number of separate unions, there were still 131 unions last year, each with a membership of less than 100. On the other hand, there were seventeen unions each with a membership exceeding 100,000.

An analysis of the industrial distribution of trade union membership in 1952 shows that in the group classified as "metal manufacture, engineering, shipbuilding, electrical goods, vehicles and other metal trades," the number of union members was 1,759,070 (1,675,760 men and 83,310 women). In 1951 the total was 1,703,840 (1,632,480 men and 71,360 women).

Notes and Memoranda

Air and Water

TISZALOK IRRIGATION PROJECT.—It is stated that the construction of the Tiszalok dam in North-East Hungary is now near completion and a date has been given for the opening of the first section of the irrigation scheme for the Hortobágy Plain. On April 4, 1954, the first 28 miles of the eastern canal, which will eventually link the Tisza and the Berettyó Rivers, will be flooded from the dam. At the same time 22 miles of irrigation branches from the main canal will come into operation. This will make possible the cultivation next spring of 35,000 acres of hitherto unproductive soil, most of which will be put down to rice.

FURTHER AIR SERVICES APPROVED.—The Minister of Transport and Civil Aviation has approved, subject to certain conditions being satisfied, the operation of three further air services. An internal service between Ramsgate, Lympne and Birmingham will be operated by Air Kruise (Kent), Ltd., and a normal scheduled service with flying boats between Southampton Water and Capri via Marseilles (Marignane) (optional traffic stop), will be operated by Aquila Airways, Ltd. Each will be operative until September 30, 1960, for the season April to September each year. An inclusive tour service between London (Gatwick) and Alghere (Sardinia) via Lyons or Marseilles (technical stops), is to be operated by Transair, Ltd., until September 30, 1955 (June to September each year), and is the third service approved.

MR. G. MCLEOD PATERSON.—We record with regret the death of Mr. G. McLeod Paterson, C.B.E., M.A., which occurred at Weston-super-Mare earlier this week. Mr. Paterson, who was sixty-two and was educated at Cheltenham College and Pembroke College, Cambridge, gained his early experience in shipbuilding with John Brown and Co., Ltd., and after serving with the Department of the Director of Naval Construction during the First World War joined the Cunard Steamship Company, Ltd. He succeeded Mr. Leonard Peskett as the company's naval architect in 1924 and continued to hold that post until he retired in 1950, due to reasons of health. During his years with the company he was associated with the liner conversion programme after the 1914–18 war and also after the Second World War, and was largely responsible for the design of the "Queen Mary" and "Queen Elizabeth." For his work on these liners he was appointed a C.B.E. in 1939.

Miscellanea

PRICES OF TUNGSTEN ORES.—The Ministry of Materials has announced that as from December 1st, its selling price for tungsten ores of standard 65 per cent grade and ordinary quality has been reduced as follows: wolframite from £10 10s. to £9 15s., and scheelite from £9 15s. to £9 per long ton unit delivered consumers' works.

BUSINESS EFFICIENCY EXHIBITION.—The first of next year's regional Business Efficiency Exhibitions to be organised by the Office Appliance and Business Equipment Trades Association will be held at Fenton Street Barracks, Leeds, from February 23 to 26, 1954. The exhibition will be the first to be held in Leeds since before the war.

INDUSTRIAL SAFETY.—An interesting booklet entitled "A Code of Safety for Employees," is now being issued by the Nuffield Organisation, Cowley, Oxford, to new employees in its factories and foundries. Of handy pocket size, this book gives in a simple, direct way advice and instruction in the safest methods of working in different departments of the factory.

SHIN-CAITHNESS TRANSMISSION LINES.—The North of Scotland Hydro-Electric Board has published details of Constructional Scheme No. 72 (Shin-Caithness Transmission Lines), which provides for the erection of transmission lines between the power stations of the Board's Loch Shin Scheme in Sutherland and for an extension of the Highland grid from the future Shin power station, near the mouth of the River Shin, to Mybster near Halkirk in Caithness.

COPPERSMITHS.—A new publication in the Central Youth Employment Executives series of books on the choice of careers deals with the trade of the coppersmith. As with the other books in the series it deals in some detail with the background, work, trade practices and prospects of the craft. The book is well illustrated and provides a very useful guide not only for youths who contemplate becoming coppersmiths but also for educationalists and those concerned with discussing their future careers.

RUBBER IN BUILDING.—The British Rubber Development Board has published four further pamphlets in its technical series dealing with the uses of rubber in building. They are entitled: "Natural Rubber Latex-Cement Compositions in Building," "Acoustics, Sound Insulation, Anti-Vibration and Thermal Insulation," "Paints Incorporating Natural Rubber," and "Rubber-Based Adhesives." Copies of these pamphlets can be obtained from the British Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3.

ELECTRIC WINDERS FOR CHISLET COLLIERY.—About thirty years ago Fraser and Chalmers Engineering Works supplied to Chislet Colliery, Kent, two compound winding engines having bi-cylindro-conical drums of 11ft 9in to 16ft diameter. In order to improve the economy of the colliery, the National Coal Board, South-Eastern Division, has decided to convert these two engines to electric drive, and has entrusted the work to the Fraser and Chalmers Engineering Works of the General Electric Company, Ltd. The converted winders will be driven through single reduction gearing by a G.E.C. a.c. motor with an R.M.S. rating of 1200 h.p. Dynamic braking and speed control will be embodied in the electrical equipment. The brake gear will also be brought up-to-date and new oil pressure-operated brake engines will be installed. The new units have been designed to raise a net load of 5 tons of coal from a depth of 1380ft and have an output of 250 tons of coal per hour.

AN APPRENTICESHIP BROCHURE.—A new brochure entitled "Opportunity for Youth," has been issued by the Fraser and Chalmers Engineering Works, Erith, Kent, giving details of its engineering apprenticeship schemes. The book opens with a brief history of the firm and its work, and then gives outlines of the schemes it has for training machinists, fitters, millwrights, toolmakers, pattern makers, moulders, electricians, carpenters, pipe fitters, boiler makers, platers and welders. Other schemes, including those for student apprentices, vacation apprentices and graduate apprentices, are also described and general information is given on the prospects open to all classes of apprentices.

EXPANSION OF B.T.H. MANUFACTURING FACILITIES.—The British Thomson-Houston Company, Ltd., has announced a programme for the expansion of its turbine production. The programme consists of two parts involving extensive re-equipment and reorganisation of the Rugby turbine plant and the erection, in Larne, Northern Ireland, of a new factory, which will concentrate on the manufacture of turbo-alternators of 30MW and upwards, and will be built alongside the turbine blading factory already under construction by the Northern Ireland Government. Manufacture of turbo-alternators below 30MW, gas turbines, marine main and auxiliary equipments, compressors, &c., will continue at Rugby but on a greatly increased scale.

SELF-REGULATING A.C. GENERATORS.—A range of self-regulating, single phase a.c. generators for unity power factor is described in a leaflet published by the manufacturer, Higgs Motors, Ltd., Birmingham, 6. No regulator is required and the excitation winding, which forms part of the main generator, is designed to produce a constant output voltage, within $\pm 2\frac{1}{2}$ per cent, on all loads of unity power factor. A series winding is included, to allow the generator to be used as a starting motor (with the help of a battery) when the machine is engine-driven; when the machine is running as an a.c. generator it also gives a d.c. output for charging a 24V battery. Four frame sizes are available, with ratings ranging from 2kVA to 7kVA at 50 c/s, 1500 r.p.m., or $2\frac{1}{2}$kVA to 9kVA at 60 c/s, 1800 r.p.m.

GOVERNMENT EXPLOSIVES IN HARBOURS.—The Service Departments and the Ministry of Supply have made new regulations which lay down the rules to be observed when Government explosives are being conveyed in harbour areas. The regulations, which will come into operation on December 10th, set out the conditions under which the loading and unloading of Government explosives may be carried out and lay down the safety precautions to be observed while the explosives are in the harbour areas. The regulations have been made by the Admiralty, the Secretary of State for War, the Secretary of State for Air and the Minister of Supply under Section 97 (5) of the Explosives Act, 1875, and replace war-time orders made by the Minister of Transport under Defence (General) Regulation 76, which comes to an end.

GAS TURBINE TECHNOLOGY COURSES.—The programme of residential courses for 1953/54 at the School of Gas Turbine Technology, Farnborough Place, Farnborough, Hants, has now been published by Power Jets (Research and Development), Ltd. Most of the courses are of from two to three weeks' duration, with tuition fees ranging from 30 guineas to 60 guineas, the additional charge for accommodation being 5 guineas a week. The courses provided are as follows: aero engine design, design and applications of industrial gas turbines, practical aero engine course and an international course on all applications of the gas turbine, all these courses being repeated several times during the year. During June, three courses—the theory and design of compressors, the theory and design of turbines, and combustion and heat exchangers—of five days' duration, have been arranged to run consecutively and cost 25 guineas each. The design courses are of post-graduate standard. The first course commenced on November 30, 1953.

"RESEARCH" ESSAY COMPETITION.—The advisory board of *Research* has announced its intention to hold another essay competition next year. The essays, which should be about 3500 words in length, must be received at the offices of *Research*, 88, Kingsway, London, W.C.2, on or before June 30, 1954. Prizes of £100 and £50 will, at the discretion of the judges, be awarded to those entries adjudged to be best and second best. In order to encourage the younger scientists, it has been decided to offer an additional sum of £50 to the best entry from a competitor under thirty years of age. Prizewinners must be able to show that they were in the period November 1, 1953, to June 30, 1954, engaged on active scientific research work (academic, industrial or Government). The choice of subject for the essay is left entirely to competitors. Judgment will be made on the choice of a suitable subject as well as the method of presentation. Credit will be given for careful consideration of possible applications of research projects. The choice of subject may be approached in two ways. The competitor may consider himself in the guise of a research director putting forward a plea for following a particular line of research work; alternatively, he may put forward a case for development work based upon research work already completed. In either case it may be assumed that the argument is to be placed before a board of directors or a committee consisting of educated men, some of them with technical training and knowledge, but without specialist knowledge of the subject matter. Competitors are invited to write to the offices of *Research* for a copy of the complete conditions.

Personal and Business

MAJOR A. G. SAUNDERS has been elected president of the British Tar Confederation.

MR. F. H. POLLICUTT, F.R.Ae.S., has been appointed chief designer of Percival Aircraft, Ltd., Luton Airport, Beds.

MR. H. B. CUNDALL has been appointed development engineer of Hunting Air Transport, Ltd., Bovingdon, Herts.

MR. A. W. DANIELS, M.I.Mech.E., has been appointed managing director of Holdan Engineers (London), Ltd., 49, St. James's Street, S.W.1.

MR. W. LYONS, chairman and managing director of Jaguar Cars, Ltd., has been elected president of the Motor Industry Research Association.

THE EFFINGHAM STEEL WORKS, Ltd., Sheffield, announces that Mr. Richard Lloyd, its London representative, has been appointed a local director.

THE LONDON MIDLAND REGION OF BRITISH RAILWAYS announces the appointment of Mr. A. H. Madden as divisional motive power superintendent at Derby.

JOHN FOWLER AND CO. (LEEDS), Ltd., Hunslet, Leeds, states that Mr. G. R. Whitehead, manager of the Sprotborough foundry, has been appointed a director.

MR. L. P. BRUNT, A.M.I.C.E., has joined Husband and Co., consulting engineers, of 388, Glossop Road, Sheffield, and 70, Victoria Street, London, S.W.1.

CROMPTON PARKINSON, Ltd., states that, as from December 7th, its London plant branch office will be situated at 1–3, Brixton Road, S.W.9 (telephone, Reliance 7676).

MR. EDWARD A. O'NEAL, JUN., chairman of Monsanto Chemicals, Ltd., has been elected a vice-president of the Monsanto Chemical Company, St. Louis, Missouri, U.S.A.

MR. S. R. MILLER has been elected chairman of Fletcher Miller, Ltd., Hyde, Cheshire, and Mr. R. T. Miller, Mrs. M. Agate, and Mr. A. George have been elected directors.

LONDON ELECTRIC FIRM, Ltd., South Croydon, announces the appointment of Mr. E. V. M. Hughes as managing director, and states that Mr. H. E. Reigate, secretary, has been appointed to the board.

MR. J. D. LEWIS, M.I.Mech.E., has relinquished his partnership in the firm of Fox and Mayo, Dashwood House, Old Broad Street, London, E.C.2. He will continue his association with the firm as a consultant.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., Parnell House, Wilton Road, London, S.W.1, states that Mr. F. H. Brooks has been appointed technical director and that Mr. Cyril Brooks has succeeded him as general works manager.

Contracts

CONTRACTS have been placed by the British Electricity Authority during November for power stations, transforming stations and transmission lines amounting in the aggregate to £8,860,590. The principal contracts include: Brunswick Wharf power station, Poplar, 132kV, 2500MVA switchgear (British Thomson-Houston Company, Ltd.); Portishead "B" power station, near Bristol, structural steelwork for turbine house and annexe, bunker bay and boiler house (Sir William Arrol and Co., Ltd.) and main and auxiliary power cables, control cables, accessories and station earthing system (W. T. Glover and Co., Ltd.); Goldington power station, Bedford, superstructures (Mitchell Construction Company), one 30MW turbo-alternator (British Thomson-Houston Company, Ltd.) and condensing and feed heating plants for one turbo-alternator set (G. and J. Weir, Ltd.); Hams Hall "C" power station, near Birmingham, 132kV, 3500MVA switchgear (A. Reyrolle and Co., Ltd.); Ocker Hill power station, Tipton, Staffs, three 180,000 lb per hour boilers (Babcock and Wilcox, Ltd., and demolition and initial site works (M. A. Boswell (Contractors), Ltd.); Stourport power station, 66kV switchgear and accessories (English Electric Company, Ltd.); Connah's Quay power station, near Flint, two 36MVA generator transformers (C. A. Parsons and Co., Ltd.); Ince power station, near Ellesmere Port, 11·8kV and lower voltage cables and connections (British Insulated Callender's Construction Company, Ltd.); Ferrybridge "B" power station, Yorks, two 760,000 lb per hour boilers (Stirling Boiler Company, Ltd.), coal handling plant (Mitchell Engineering, Ltd.), and one 120MVA generator transformer (C. A. Parsons and Co., Ltd.); Marchwood sub-station, near Southampton, site and foundation works (Jno. Croad, Ltd.); Dudley sub-station, Worcs, 132kV, 2500MVA switchgear (General Electric Company, Ltd.); Monk Fryston sub-station, Yorks, 275kV, 7500MVA switchgear (British Thomson-Houston Company, Ltd.); and Penwortham sub-station, near Preston, 132kV overhead lines (British Insulated Callender's Construction Company, Ltd.).

British Patent Specifications

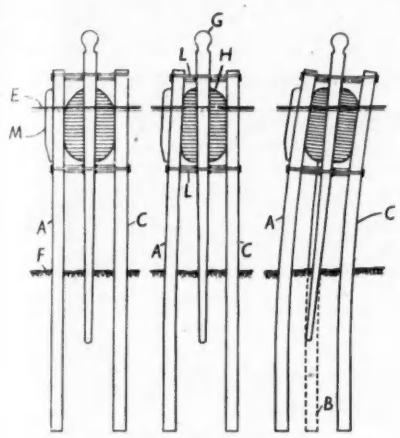
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MARINE ENGINEERING

699,624. October 8, 1952.—AN ELASTIC MOORING DOLPHIN, Guy Anson Maunsell, 41, Abbey House, Victoria Street, Westminster, London, S.W.1.

As shown in the drawing, the dolphin consists of four broad flanged rolled steel beam piles, *A*, *B*, *C* and *D*, driven through water *E* and ground *F* in the form of a ring surrounding a central post or kingpin *G*. A rope coir buffer ball *H* wound round the post *G* contacts the inner faces of the piles in the centres of which timber packings *J* are fixed. Wire rope bindings *K* press the piles against the buffer ball and cross lacings of wire rope *L* hold together



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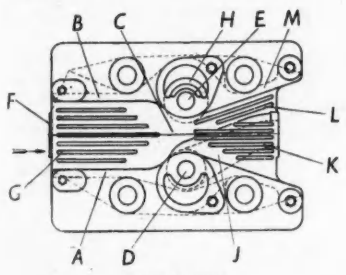
the opposite piles *A* and *C*, also *B* and *D*. A timber rubbing fender *M* is fixed outside pile *A*. When the fender receives the blow of an impacting ship pile *A* bends over, squeezing the buffer ball, as shown in the middle view. As the ship's impact develops the pressure is transmitted through the fender and the buffer ball to the pile *C* which in turn commences to bend over to the right dragging with it piles *B* and *D* through wire ropes *K* and *L*. The third view shows the dolphin bent over under the fully developed impact in which position the flexure of the four piles, *A*, *B*, *C* and *D* must not exceed the elastic limit of deformation.—*November* 11, 1953.

INTERNAL COMBUSTION ENGINES

699,554. October 22, 1951.—CYLINDER HEADS OF AIR-COOLED ENGINES, Porsche Konstruktionen G.m.b.H., 5, Alpenstrasse, Salzburg-Morzg, Austria.

This invention relates to cylinder heads for air-cooled internal combustion engines with a cooling channel swept through by the cooling air, and com-



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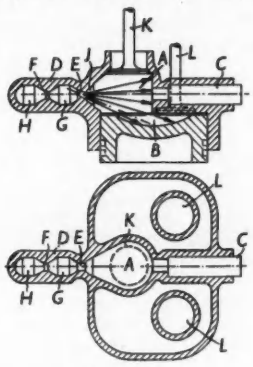
prising an external recess open along its entire length to the exterior of the engine through the upper surface of the cylinder head and extending between the valve guides. As shown in the drawing, the cooling air is blown in the direction of the arrow towards the cylinder head and is divided up by vertical walls *A* and *B* into a central and two lateral air streams. In this way a cooling channel or recess *C* is formed, which extends across the cylinder head. At the valve guides *D* and *E* the recess narrows down to form a nozzle. The cooling recess is disposed above the combustion chamber *F* and is open along its entire length to the exterior of the engine. Above the combustion chamber vertical cooling ribs *G* are arranged. According to the invention, suction duct *H* is substantially vertical—that is, parallel to the longitudinal axis of the cylinder, through the cylinder head. Through this arrangement the space otherwise required for the suction duct becomes free and it becomes possible to arrange the exhaust duct *J* to extend from the exhaust valve substantially perpendicular to the suction duct under the cooling channel or recess *C* and lengthwise through the cooling recess. This also provides more space for the recess, so that it can be widened considerably behind the valve guides. It also gives more space for the greater number of ribs in the recess for conveying away the heat. In the cooling recess there are provided above the exhaust duct parallel to the longitudinal centre plane ribs *K*, whilst other oblique ribs *L* are arranged laterally of the rib *K* and parallel to the diverging guiding walls *M* of the cooling recess. In this way the cooling and conveying away of heat in the hot part of the cylinder head, lying next to the exhaust duct, is substantially improved.—*November* 11, 1953.

698,945. March 14, 1950.—COMPRESSION-IGNITION ENGINES WITH ENERGY CELL, Lanova A.-G., 16, Bahnhofstrasse, Zurich, Switzerland.

The invention relates to compression-ignition engines having an energy cell to discharge an expanding jet into a single cell combustion chamber arranged partially in the cylinder head and partially in the piston. In the drawings *A* is the main combustion chamber part formed in the cylinder head, *B* is the piston cavity, *C* the fuel injection nozzle, *D* the energy cell arranged opposite the nozzle, *E* the energy cell mouth, *F* the cross-sectional contraction subdividing the energy cell into two sections *G* and *H* arranged one behind the other, *J* is a funnel arranged in front of the energy cell mouth, *K* the valve, usually the



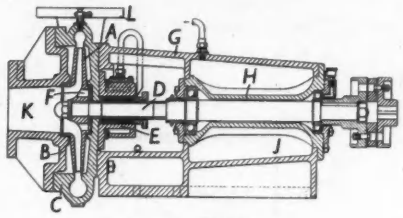
No. 698,945

exhaust valve, and *L* the second main valve. As shown, two such valves can be provided. The cross section of the single cell combustion chamber *A* in the cylinder head is so shaped in a plane perpendicular to the cylinder bore axis as to present straight sides diverging from adjacent the mouth until they merge into a rounded end. The energy cell *D* is subdivided by the contraction into the two compartments. The axis of the energy cell mouth points into the piston cavity. The axes of the nozzle end of the energy cell are in line with each other. The top wall of the combustion chamber part *A* which faces the cylinder bore and includes the exhaust valve seating, is inclined with respect to the axis of the mouth of the energy cell so that its distance from the axis increases with increasing distance from the mouth of the cell, being partly perpendicular and partly inclined to the cylinder bore axis. Four other alternative designs are given in the specification.—*October* 28, 1953.

PUMPS

697,561. August 8, 1951.—HIGH-TEMPERATURE HOT WATER CENTRIFUGAL PUMPS, The Hobdell Engineering Company, Ltd., 39, Victoria Street, London, S.W.1. (*Inventor: Charles Leslie Kempton.*)

In the drawing, the pump has an impeller *A*, revolving in a fixed double casing *B* and *C*, and mounted at the end of the driving shaft *D*. A water-cooled gland *E* is fitted, and the impeller is hydraulically balanced by two apertures *F*. Two bearings are provided, a ball bearing to prevent axial movement of the shaft relative to the outer casing *G*, and a roller bearing to allow for axial expansion of the shaft. Between the bearings is an axial ribbed housing member *H*, machined to contact the shaft at points near the two ends of the housing. The central part of the housing *H* has a substantial clearance, which can be packed with grease. This housing also constitutes the inner wall of a water jacket space *J* for cooling the bearings, and the shaft between them.



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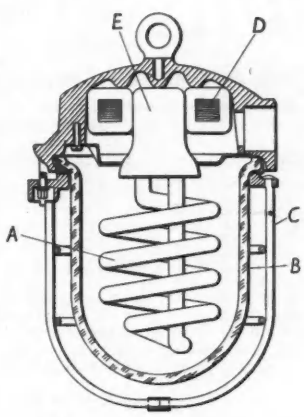
Cooling water is admitted by the pipe shown. The hot water to be pumped enters at *K* and is discharged through the outlet *L*. With the arrangement described thermal contact with the driving shaft is made at both ends of the housing member *H* in order to conduct heat to the water jacket.—*September* 23, 1953.

MINING ENGINEERING

699,478. June 6, 1951.—MINE LAMP WITH FLUORESCENT TUBE, Dominitwerke G.m.b.H., Hoppecke, Kreis Brilon, Germany.

A fluorescent discharge tube *A* of helical form is in a space enclosed by a protective fitting formed by a transparent globe *B* and protected against damage by a wire guard *C*. A ring transformer *D* transforms the



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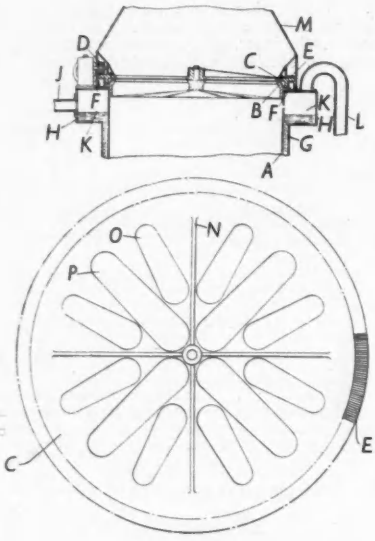
applied 220V supply into high-voltage which serves for igniting and operating the tube. A member *E* provided in the central hollow space of the transformer supports both ends of the tube *A* and its electrical connections. The advantage claimed is that, even when the protective globe and the tube are broken, no ignition by fire-damp can occur.—*November* 11, 1953.

FURNACES

696,682. August 14, 1950.—GAS PRODUCERS, Reginald Vandezee Farnham, 15, Mount Ephraim Road (formerly of 17, Guildford Road), Tunbridge Wells.

The drawing shows the invention applied to the ordinary form of gas producer. It will be noted that the usual top feed arrangement and the water jacket to the top shell *A* are omitted. In its place there is a fixed plate *B* which is furnished with a number of openings as shown in the lower view, and may be of varying size and shape. Above the fixed plate is a rotary plate *C* having a similar series of holes. This plate is rotated by a motor-driven pinion *D* engaging a toothed ring on the edge of the plate *E*. The rotary plate *C* is mounted on roller bearings *F*. To compensate for the loss of water jacket space the walls of the shell *G* are enlarged to a diameter *H*. Air is admitted by the pipe *J* to the steam space *K* and the air and steam mixture is led to the bottom of the producer by the pipe or pipes *L*. Above the plates is the hopper *M*, with a shutter to prevent the loss of gas. The design and spacing of the slots in the feed plates give a substantially uniform depth of fuel bed throughout the entire cross-section of the producer shell. An extremely uniform quality of producer gas is formed, whilst the thickness and density of the fuel bed is maintained substantially constant, irrespective of the load demand on the producer. To achieve these

ends it will be noted that the rotating plate in the lower view has ribs *N* with two series of radial openings *O* and *P*, tapering so as to be narrower



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at the periphery where the speed is greater than at the centre. In the specification a modified form of fixed plate with a central bearing is also shown.—*September* 9, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, *Park Street, London, W.*1.

DIMENSIONS OF X-RAY FILMS FOR CRYSTALLOGRAPHY

No. 2030 : 1953. Price 2s. The special needs of crystallographers cannot be satisfactorily met by the sizes of X-ray film specified in B.S. 1443 : Sizes of X-ray Film and Intensifying Screens ; and the new standard B.S. 2030 has therefore been prepared to deal with the sizes of X-ray film used in the various instruments peculiar to the crystallographer, e.g. diffraction powder cameras, as specified in B.S. 1693. It is hoped that it will give guidance relating to the future design of crystallographic equipment and apparatus.

BRITISH STANDARDS FOR WORKSHOP PRACTICE

B.S. Handbook No. 2 : 1953. Price 21s. Forty-one of the most vital standards to engineers, draughtsmen and engineering students, have been collected in the 1953 edition of this handbook. Analogous standards have been grouped into seven sections, namely those dealing with Limits and Fits ; Screw Threads ; Gauges ; Bolts, Nuts and Metal Thread Screws ; Cutting Tools ; Machinery Details ; and Miscellaneous Data.

Included in this reprint are several specifications, the basic data for which has received acceptance on both sides of the Atlantic, notably those standards for Unified Screw Threads and for Limits and Fits.

METHODS OF TESTING RAW RUBBER AND UNVULCANISED COMPOUNDED RUBBER. PART 4 : EVALUATION OF VULCANISING CHARACTERISTICS.

No. 1673 : Part 4 : 1953. Price 3s. 6d. The testing methods given in this part of B.S. 1673 are applicable to raw natural rubber and are intended for use in evaluating such rubber on the basis of technically important properties.

The evaluation of the vulcanising characteristics of a raw natural rubber consists in (*a*) mixing a sample of the rubber in accordance with one or more standard formulations, (*b*) testing the tendency of the compounded stock to scorch, (*c*) vulcanising the compounded stock for one or more times at a fixed temperature, and (*d*) testing the properties of the vulcanisates so produced by (i) modulus or elongation measurements (three alternative methods being detailed), and (ii) swelling measurements.

In general, the magnitude of any physical property of the vulcanisate depends on the time and temperature of vulcanisation and in some cases a maximum or minimum value is reached. Furthermore, rubbers obtained from different sources and prepared in different ways differ from one another in both the magnitude of this maximum or minimum value and the time of vulcanisation required.

This standard specifies the text mix and vulcanisation conditions to be used and describes the scorch test for unvulcanised compounded stock as well as the procedures for the following tests on the vulcanisate:—The strain of elongation produced by a constant stress of 5 kg per square centimetre ; the modulus at 100 per cent elongation ; the modulus at 600 per cent elongation ; and swelling in benzene.

80 OZ. AND 90 OZ. WINCHESTER BOTTLES

No. 830 : 1953. Price 2s. In 1939 the B.S.I. issued a standard for Winchester bottles at the request of the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association. Because of the wartime difficulties of supply the standard was not widely used and a revision has now been prepared which is consistent with current practice. The new standard for 80 oz and 90 oz Winchester bottles, relates to plain and fluted containers and in order to facilitate storage and outer packaging the same maximum diameter has been adopted for both kinds in each capacity. Alternative kinds of neck finishes are provided.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Dec. 9th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, A Symposium on Vibration Methods of Testing, 6.30 p.m.——N.E. SECTION : Neville Hall, Westgate Road, Newcastle upon Tyne, "The Effects of Aural Disturbances on Audio Production," M. Anderson, 6 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Dec. 7th.—Cleveland Scientific and Technical Institution, Corporation Road, Middesbrough, "Gasholders, with special reference to the Steel Industry," T. H. Riley, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Dec. 8th.—MANCHESTER BRANCH : Engineers' Club Albert Square, Manchester, "The Use and Application of Mobile Plant," J. L. Sturrock, 7.15 p.m.
Wed., Dec. 9th.—E. MIDLANDS BRANCH : Gas Board Showrooms, Parliament Street, Nottingham, "The Failure of Metals," J. A. Pope, 7 p.m.
Thurs., Dec. 10th.—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, ten-minute papers by Members, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 7th.—S. WALES SECTION : S. Wales Institute of Engineers, Cardiff, "Operation of a Marine Gas Turbine Under Sea Conditions," J. Lamb and R. M. Duggan, 7 p.m.
Wed., Dec. 9th.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "The Basic Principles of Lubrication," G. N. Clark, 7.30 p.m.
Thurs., Dec. 10th.—JUNIOR LECTURE : Technical College, Kingston, "Marine Diesel Engines," A. G. Arnold, 2.15 p.m.——Technical College, Acton, "Marine Diesel Engines," A. G. Arnold, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Dec. 9th.—26, Portland Place, London, W.1, "Stores Control," R. C. H. Toye, 5.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Thurs., Dec. 10th.—Smithfield Show and Agricultural Machinery Exhibition, Richmond Hall, Earl's Court, London, "Designs of Fertiliser Distributors and Their Mechanisms," G. W. Cooke, 3 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Dec. 8th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Problems of Biochemical Engineering," J. J. H. Hastings, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 8th.—STRUCTURAL AND BUILDING MEETING : Great George Street, Westminster, London, S.W.1, "A Moment Distribution Method for the Analysis and Design of Structures by the Plastic Theory," M. R. Horne, 5.30 p.m.
Thurs., Dec. 10th.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, "The Construction of a Three-Storey Warehouse in Presressed Concrete at Sighthill, Edinburgh," R. W. Pearson, 6.30 p.m.——MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Some New Bridges in Germany," C. S. Chettoe, 6 p.m.
Fri., Dec. 11th.—YORKSHIRE ASSOCIATION : Royal Station Hotel, York, "The Principles of Railway Signalling and Modern Trends," A. F. Wigram, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Dec. 7th.—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Radio Aids for Airport Control," E. J. Dickie, 6 p.m.——INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "The Ridley Report," opened by C. T. Melling, 5.30 p.m.
Tues., Dec. 8th.—MEASUREMENTS SECTION : Savoy Place, London, W.C.2, "The Determination of Optimum Process-Controller Settings and their Confirmation by Means of an Electronic Simulator," R. L. Ford ; "The Effects of the Addition of Some Non-Linear Elements on the Transient Performance of a Simple R.P.C. System Possessing Amplifier Saturation," J. C. West, J. L. Douce and R. Naylor ; "The Step Function Response of a R.P.C. Servo Mechanism Possessing Torque Limitation," J. C. West and I. R. Dalton, 5.30 p.m.——N. MIDLAND CENTRE : The University, Leeds, "Some Applications of Electronics," T. G. Bridgwood, 6.30 p.m.——LONDON STUDENTS' SECTION : Public Library, Chelmsford, "Electrica Contacts," E. M. Briscoe, 7 p.m.——EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "The Teaching of Electrical Machine Design," opened by M. G. Say, 6 p.m.
Thurs., Dec. 10th.—UTILIZATION SECTION : Savoy Place, London, W.C.2, "Electric Lifts in Post-War Housing," C. G. L. Morley, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Dec. 9th.—LEEDS BRANCH : Church Institute, Albion Place, Leeds, Films, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 4th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, "Comparative High-Temperature Properties of British and American Steels," W. E. Bardgett and C. L. Clark, "A Critical Examination of Procedures Used in Britain and the United States to Determine Creep Stresses for the Design of Power Plant for Long Life at High Temperatures," R. W. Bailey, 5.30 p.m.
Mon., Dec. 7th.—N.E. BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Relaxation Methods : A Retrospect," Sir Richard Southwell, 6 p.m.——AUTOMOBILE DIVISION : Storey's Gate, St. James's Park, London, S.W.1, "Functions of Materials in Bearing Operation," P. P. Love, P. G. Forrester, and A. E. Burke, 5.30 p.m.——S. WALES BRANCH : S. Wales Institute of Engineers, Cardiff, "Planning and Design of the Refinery Expansion Project at Llandarcy," I. Cameron, 6 p.m.
Wed., Dec. 9th.—E. MIDLANDS BRANCH : County Technical College, Newark-on-Trent, "Recent Researches into the Machinability of Steel," K. J. B. Wolfe, 7.30 p.m.
Thurs., Dec. 10th.—YORKSHIRE BRANCH : The University, Leeds, "Relaxation Methods : A Retrospect," Sir Richard Southwell, 7 p.m.
Fri., Dec. 11th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, "Practical Training in Industry for the Graduate in Mechanical Engineering," K. R. Evans, H. W. Fulton, R. S. Medlock, D. P. Lant and J. A. Pope, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Fri., Dec. 11th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Maintenance of T.V. Links," C. E. E. Clinch and L. Thomas, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Dec. 9th.—PRESTON SECTION : Crown Hotel, Blackburn, "Production Engineers of the Future," E. C. Gordon England, 7.15 p.m.——WESTERN SECTION : Grand Hotel, Broad Street, Bristol, "Tube Manufacture and Manipulation," L. C. Hackett and A. N. Attwood, 7.15 p.m.
Thurs., Dec. 10th.—COVENTRY SECTION : Geisha Cafe, Hertford Road, Coventry, "Recent Developments in Labour Incentive Systems," N. A. Dudley, 7 p.m.
Fri., Dec. 11th.—W. WALES SECTION : Central Public Library, Alexandra Road, Swansea, "Leadership," K. C. Appleyard, 7 p.m.

INSTITUTION OF SANITARY ENGINEERS

Thurs., Dec. 10th.—Caxton Hall, Westminster, London, S.W.1, Discussion on "Engineering Problems Concerned with the Treatment of Various Types of Trade Effluent," opened by G. T. Cotterell, 6 p.m.

IRON AND STEEL INSTITUTE

Thurs., Dec. 10th.—IRON AND STEEL ENGINEERS' GROUP : 4, Grosvenor Gardens, London, S.W.1, Twenty-fourth Meeting, 10.30 a.m. to 12.45 p.m., "Belt Charged Blast-Furnaces of S. A. John Cockerill, Belgium," G. Hookam ; 12.45 p.m. to 2.0 p.m., Buffet Luncheon ; 2.0 p.m. to 4.0 p.m., "The Iron-making Plant at the Shotton Works of John Summers and Sons, Ltd.," J. F. R. Jones and A. Walker.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 4th.—Townsend House, Greycoat Place, London, S.W.1, Film Evening, 7 p.m.
Mon., Dec. 7th.—N.W. SECTION : Engineers' Club, Albert Square, Manchester, "Shell Moulding," F. Burgess, 7 p.m.
Fri., Dec. 11th.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Presidential Address, "Developments and Future Possibilities in Electricity Generation," Sir John Hacking, 7.30 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Dec. 9th.—24, Dale Street, Liverpool, "Some Aspects of Power Station Design and Construction," W. H. C. Pilling, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Dec. 10th.—Liverpool Engineering Society, 24, Dale Street, Liverpool, "Bearings and Bearing Alloys," P. T. Holligan, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Dec. 11th.—Mining Institute, Newcastle upon Tyne, "Vibration Tests on an Up-River Collier with special reference to the Influence of Depth of Water," A. I. Johnson and W. J. Marwood, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Dec. 9th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Principles and Practical Applications of the Partial Prestressing of Concrete," P. W. Abeles, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Dec. 10th.—BELFAST BRANCH : Whitla Hall, Methodist College, Belfast, "Training Devices for Air Crew," C. B. Ringham and A. E. Cutler, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Dec. 7th.—12, Great George Street, Westminster, London, S.W.1, "The Ordnance Survey and Archæology," C. W. Phillips, 5.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Dec. 7th.—College of Commerce and Technology, Pond Street, Sheffield, "Shell Moulding," J. Fallows, 7.30 p.m.

SOCIETY OF ENGINEERS

Mon., Dec. 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Recent Development of Resistance Welding in relation to the Automobile Industry and Modern Welding Trends in Light Alloy Welding," C. E. Slade, 5.30 p.m.

TIMBER DEVELOPMENT ASSOCIATION

Mon., Dec. 7th.—Gas Show Rooms, Manchester, "Chemical Action of Timber," C. H. Gobie, 7 p.m.